(Established 1832.)
AMERICAN ENGINEER AND RAILROAD JOURNAL.

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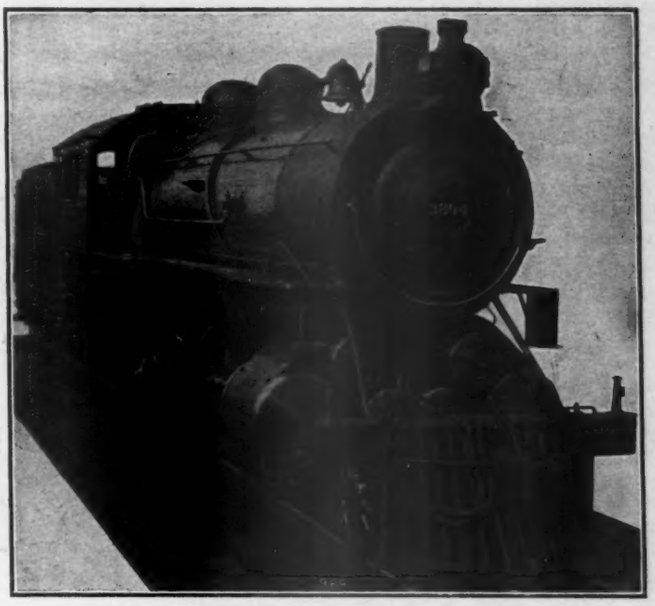
VAUCLAIN 4-CYLINDER BALANCED COMPOUND LOCOMOTIVE.

4—4—2 TYPE—NEW YORK CENTRAL RAILROAD.

In this journal, in May, 1904, page 184, the Cole 4-cylinder balanced compound, built for this road by the American Locomotive Company, was described. In February, 1901, page 35, the original Atlantic type simple engine of this road was illustrated, which has proven to be one of the most satisfactory designs ever introduced on that road. This original Atlantic type locomotive is the basis for the application of both the Cole and Vauclain balanced systems on this road, and from the results already obtained by the Cole locomotive on the St. Louis testing plant, and by the Vauclain on the Burlington, the 4-cylinder balanced type of construction seems sure to prove exceedingly successful. The Vauclain locomotive happens to be the 25,000th turned out from the Baldwin Works, and it is of interest to know that the Plant system balanced engine, illustrated in March, 1902, page 72, was the 20,000th from these works, 5,000 locomotives having been turned out in three years.

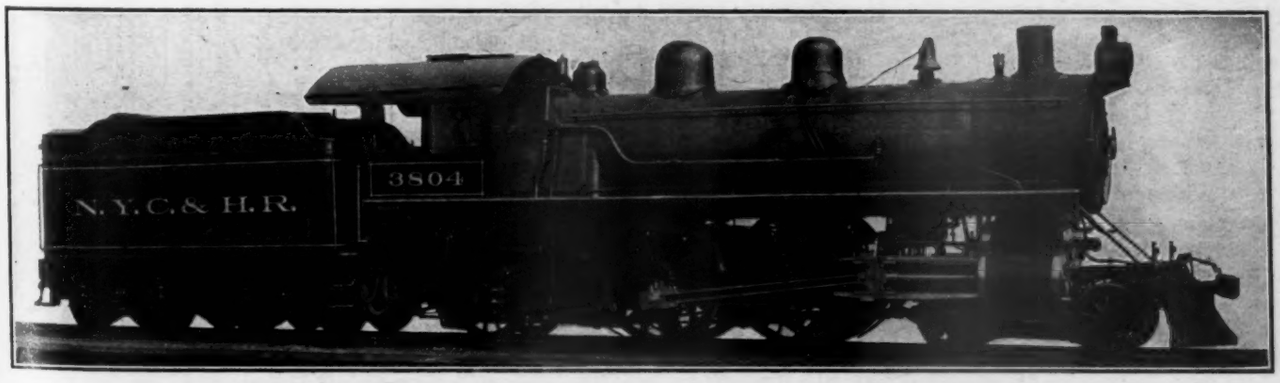
The Vauclain design brings one low and one high pressure cylinder into the same casting. The high pressure cylinders connect with the crank axle and the low pressure with the crank pins of the rear driving wheels, thus dividing the engine, and yet the cylinders are not separated as in the Cole and De Glehn arrangements. The crank axle is built up, with circular crank cheeks, the construction being almost exactly the same as that of the New York, New Haven & Hartford engine, illustrated in December, 1904, page 466. The eccentrics are driven by the rear axle and the valve stem passes immediately over the frames and is perfectly straight, the center of the piston valve being over the center of the frames.



FRONT VIEW, SHOWING ELEVATION OF CYLINDERS AND PISTON VALVES.

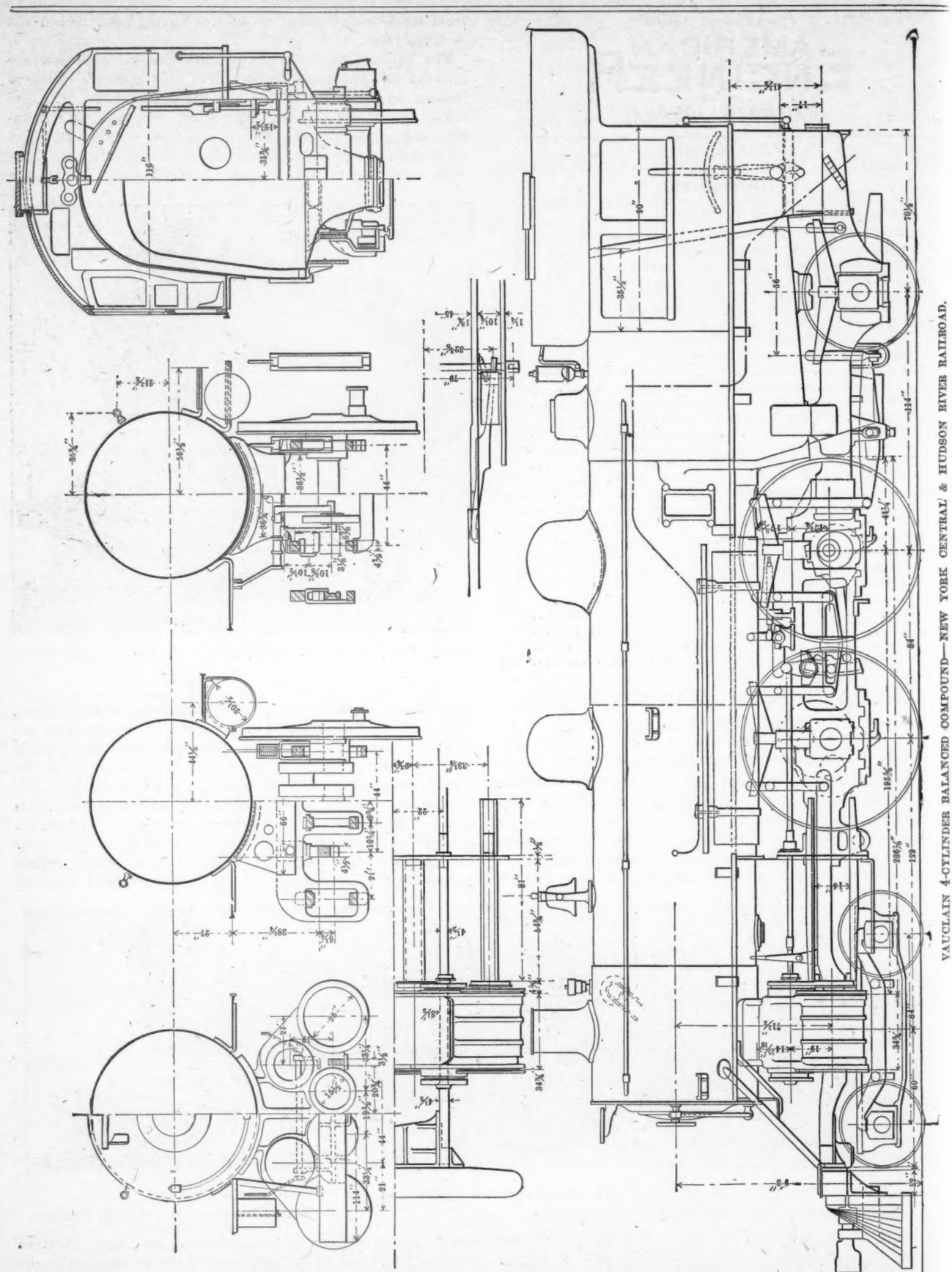
In order to secure as long inside main rods as possible, this cylinder arrangement required an increase of wheel base, an increase in the length of tubes, long outside guides and other changes in details, which are indicated in the accompanying comparison of the simple locomotive and the two balanced compounds presented in the accompanying table. Instead of using 2-in. tubes 16 ft. long, the new design employs 2¼-in. tubes 18 ft. 6 ins. long. The boiler is straight as before and the firebox is unchanged, but the heating surface is slightly increased. The tractive power is 24,200 lbs.

The low pressure cylinders have the usual relief valves, but the relief valves for the high pressure cylinders are replaced by a single valve connected with the T head located on top of the smokebox, just in the rear of the stack. Air admitted at



VAUCLAIN 4-CYLINDER BALANCED COMPOUND—NEW YORK CENTRAL & HUDSON RIVER RAILROAD.

J. F. DEEMS, *General Superintendent of Motive Power.* BALDWIN LOCOMOTIVE WORKS, *Builders.*



VAUCLAIN 4-CYLINDER BALANCED COMPOUND—NEW YORK CENTRAL & HUDSON RIVER RAILROAD.

this point becomes heated in passing down through the steam pipes before it reaches the cylinders, which should be an advantage.

In general the new design resembles in its principal details the original engine and the Cole compound, the details being sufficiently similar to permit of a satisfactory comparison of the different arrangements of cylinders. It will be noted that the cylinders are exactly the same in diameter in both of the compounds. The leading dimensions of the three designs mentioned may be compared by aid of the accompanying table.

While the frames are necessarily different from the others, in order to accommodate the increased length of wheel base and the cylinders in one casting, in general they are similar to the other two designs. The front driving journals are 10 x 10¾ ins., the rear 9½ x 12 ins. The truck wheels are 36 ins. with 6¼ x 10-in. journals, the trailing wheels being 50 ins.,

with 8 x 14-in. journals. Ten tons of coal and 6,000 gals. of water are carried on the tender, which is New York Central standard. The comparative table of dimensions follows:

NEW YORK CENTRAL ATLANTIC TYPES COMPARED.

Type—Drivers	4-4-2	4-4-2	4-4-2
Type—Name	Atlantic	Atlantic	Atlantic
Number of road or class	980	3000	3804
Builder	Sch'n't'dy	Cole	Baldwin
Simple or compound	Simple	Balanced. Compound	Balanced Compound
When built	1901	1904	1905
Weight, engine total, lbs.	176,000	200,000	204,500
Weight, on drivers, lbs.	94,800	110,000	106,820
Weight, on leading truck, lbs.	42,600	50,000	53,460
Weight, on trailing truck, lbs.	38,600	40,000	44,220
Weight of tender (loaded), lbs.	112,000	121,600	120,500
Wheel base, driving, ft. and ins.	7-0	7-0	7-0
Wheel base, total, engine, ft. & ins.	27-3	27-9	30-9
Wheel base, total engine and tender, ft. and ins.	53-0	53-8	56-3
Driving wheels, diameter, ins.	79	79	79
Cylinders, diameter, ins.	21	15½	15½ & 26
Cylinders, stroke, ins.	26	26	26
Heating surface, firebox, sq. ft.	180	175	180
Heating surface, arch tubes, sq. ft.	27.1	23	
Heating surface, tubes, sq. ft.	3,298.1	3,248.1	3,465
Heating surface, total, sq. ft.	3,505.2	3,446.1	3,645
Firebox, length, ins.	96⅛	96⅛	96⅛
Firebox, width, ins.	75⅝	75¼	75¼
Grate area, sq. ft.	50.3	50.23	50.3
Boiler, smallest diameter of, ins.	72	72¼	72⅛
Boiler, height of center above rail, ft. and ins.	9-3	9-3 1-16	9-3
Tubes, number & diameter in ins.	396-2	390-2	318-2¼
Tubes, length, ft. and ins.	16-0	16	18-6
Steam pressure, lbs., per sq. in.	200	225	
Type of boiler	Straight	Straight	Straight
Fuel	Bitum. coal	Bitum.	Bitum.
Reference in American Engineer and Railroad Journal	Feb., 1901 P. 35	May, 1904 P. 184	April, 1905

IMPRESSIONS OF FOREIGN RAILROAD PRACTICE.

EDITORIAL CORRESPONDENCE.

PARIS.

In estimating the value of foreign railway practice it is wise to look beyond the equipment itself. We can not use foreign locomotives or cars and foreigners cannot use ours, simply because they would be misfits, being developed to meet entirely different conditions. Americans return from abroad saying that we have little to learn from foreigners. Their cars are mere boxes and their locomotives are small. This is true, but if we look deeper and discover the foreign methods of developing their equipment and the methods of operating it we find a wealth of ideas which are worthy of study and emulation. This applies to France, to England, and to Germany. In France, where I found the mechanical engineering as well as the operation of the locomotive carried to the highest point, the motive power officials themselves are worthy of study. These gentlemen stand among the highest engineers of the country. Their work is appreciated and they have performed a very important part in the transportation development of the continent.

One characteristic of their work is that of knowing what is to be required and providing for it carefully in advance. They occupy leading positions in railway administrations and are consulted. No administration in France would dare to take the responsibility of ordering locomotives without depending absolutely upon the motive power department for the design, and even the smallest detail is left to these officials. Anything else would be contrary to the precedents, the traditions and the business policy of the roads. The result is that the locomotive responsibility rests entirely with these officials (in marked contrast to conditions on some of our roads at home).

To me there is a deep significance in the fact that French locomotives are provided with devices which are perfectly well handled and which we have not been able to use because of their "complication." One of these is the variable exhaust. French runners are taught to use them and they do use them intelligently, economically and efficiently. The question arises as to why we cannot do likewise, because we need the variable exhaust.

French motive power men have produced machines which are admirably suited to their needs. Their one thought has been to secure the best, and they have brought up the men to handle machines which are very complicated, as judged from our standards. We may criticize construction for lack of convenience in repairs, but we must bow to the traditions under which these officials really direct their departments and conduct their work in accordance with high ideals. To do this they have enjoyed real co-operation with other departments.

I wish specially to acklowledge courtesies received from Messrs. du Bousquet and Rodrigue, of the Northern; Messrs. Solacroup and Laurent, of the Orleans, and Mr. Herdner, of the Southern Railway, with whom I spent most enjoyable but brief moments. The atmosphere of their departments produced a feeling like inspiration, because of the appreciation of the locomotive problem which is everywhere evident. It gives the impression of the commanding importance of motive power and of the officials who have brought the French locomotive to its high place, and have at the same time developed the men to operate them. The perfection of the premium system for locomotive engineers and firemen, used so effectively in France, entitles these officials to the highest praise, particularly those of the Nord, Midi and Paris-Orleans railways. I was not fortunate enough to personally inspect the good work which I know the other roads are doing.

FREIGHT CARS IN FRANCE.

Because French freight equipment is not of large carrying capacity it does not follow that it has no interest for us. These people have much to show us in the use of steel frames. They have adopted steel in light equipment for reasons of economy in maintenance. The moral of this is that if economical where steel is not required for strength, it must necessarily be even more economical for us, because we need the strength of steel as well as its durability. These roads have used iron under-frames for more than 40 years. Since 1869 all the cars of the Eastern Railway have had metal underframes. In this experience the value of the superior resistance to corrosion of large sections has been learned and life of 60 years is expected, or three times the life of wooden frames. What more could be asked?

These cars are from 15 to 25 ft. long and of about 10 tons capacity. Few of them have even hand brakes. If steel frames are advantageous under these conditions, what is to be said of them for ours?

In France steel has replaced wood and the frames were at first too light, many of the older ones being of special rolled sections resembling a letter E. Composite frames succeeded wooden ones, but now the frames are entirely of steel, while in Germany many cars are built entirely of steel. Generally the underframes employ 3 or 5 longitudinal sills of channels or I beams, gussetted to 4 cross bearers and provided with diagonal braces. On these wooden boxes are built.

Each road has as small a number of different types of underframes as possible, but the superstructures are varied to suit traffic requirements of shippers. Most of the cars are built in the shops of the railroads and by the repair forces when not otherwise occupied. In this way the repair organizations are kept together. The repair forces are small because, except for wrecks, the maintenance of the frames is almost insignificant. These people do not know anything of the effect of heavy American locomotives, of our strenuous methods and the destructiveness of our switchmen. As to the corrosion of steel frames, there is not the slightest anxiety in France.

It seems difficult to believe, but I am told that thousands of French cars are maintained for less than $2 per car per year, which, however, does not include painting. A thorough painting once in 3 years is believed to be sufficient to maintain steel underframes satisfactorily. New equipment is provided in accordance with appropriations upon an annual depreciation basis. This was mentioned by Mr. Tolmer, of the Eastern Railway of France, in his article in this journal in April, 1897. On page 120 of that number an interesting diagram of the cost of repairs of French cars was presented. I am

told that this diagram applies to-day. Steel underframes are overhauled when about 15 years old, very little work being required in intervals of 15 years after that. As far as I can learn no metal frames of the heavier sections in ordinary service have ever worn out or corroded to the point requiring them to be discarded. It is apparent that the cost of repairs of the wooden boxes is far greater than that of the metal frames of the same cars.

These people cannot understand our general use of wooden cars for either passenger or freight service. Passenger car construction over here is tending in a marked way toward universal use of steel underframes and increasing use of steel in upperframes. An excellent example of metal work is the metallic window sash of European cars.

My notes cover many other interesting details, but these letters must soon be brought to a close.

G. M. B.

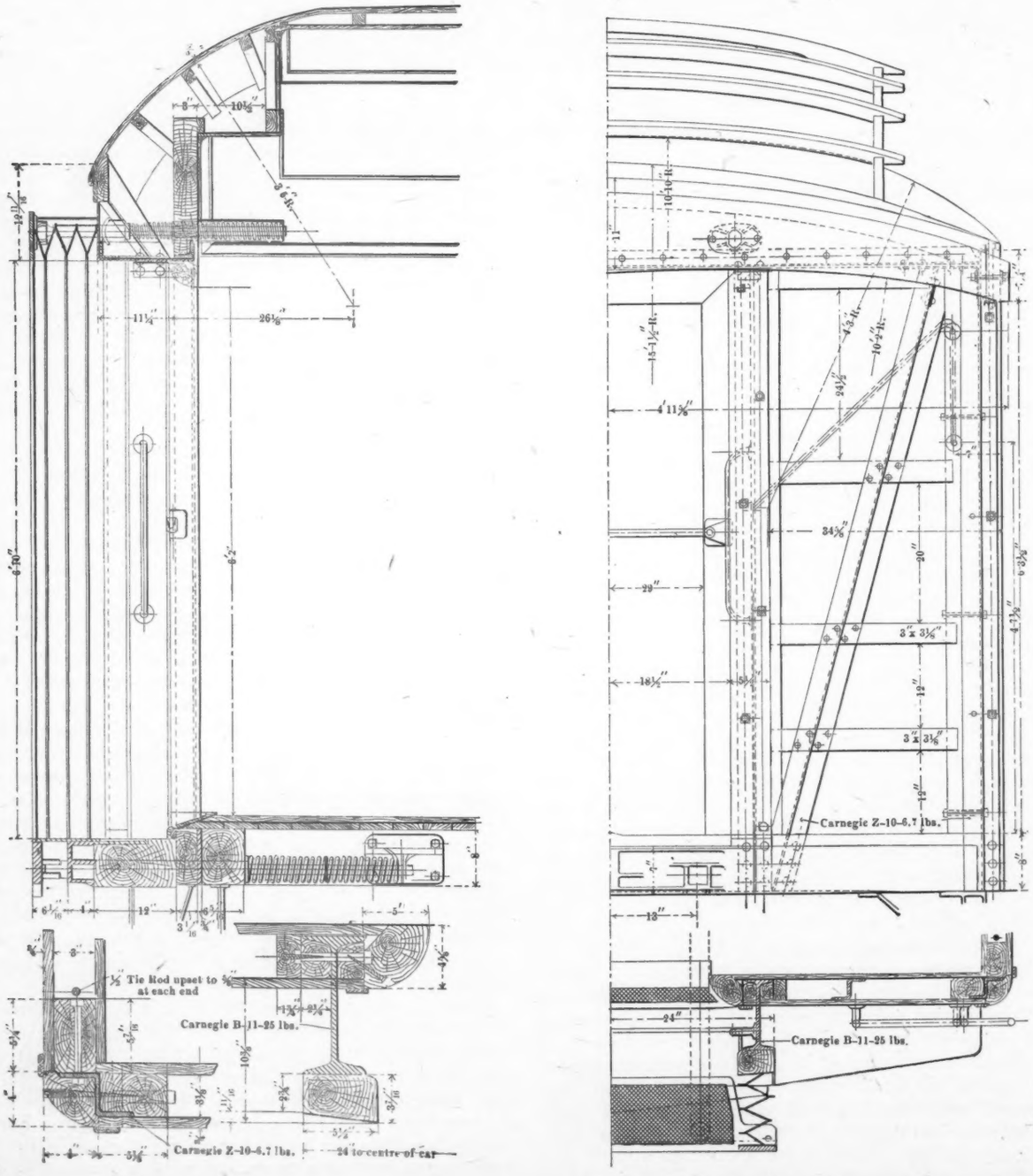
(To be continued.)

REINFORCEMENT OF POSTAL CARS.

PENNSYLVANIA RAILROAD.

In accordance with suggestions from the United States mail service officials, the end construction of postal cars on the Pennsylvania Railroad has been reinforced, as shown in these engravings. The reinforcement provided is even more effective than that suggested. Its purpose is to increase collision resistance.

In addition to the plates applied to the outside faces of the center sills and the inside faces of the side sills and the outside faces of the end sills, large rectangular castings are applied at the corners of the underframe; the end framing is reinforced in an entirely new way. The ¾ x 8-in. plate reinforcing the end sills receives the attachment of 10-in. 25-lb I beams, forming posts for the vestibule opening. Across these I beams at the top is a horizontal plate with flanges of

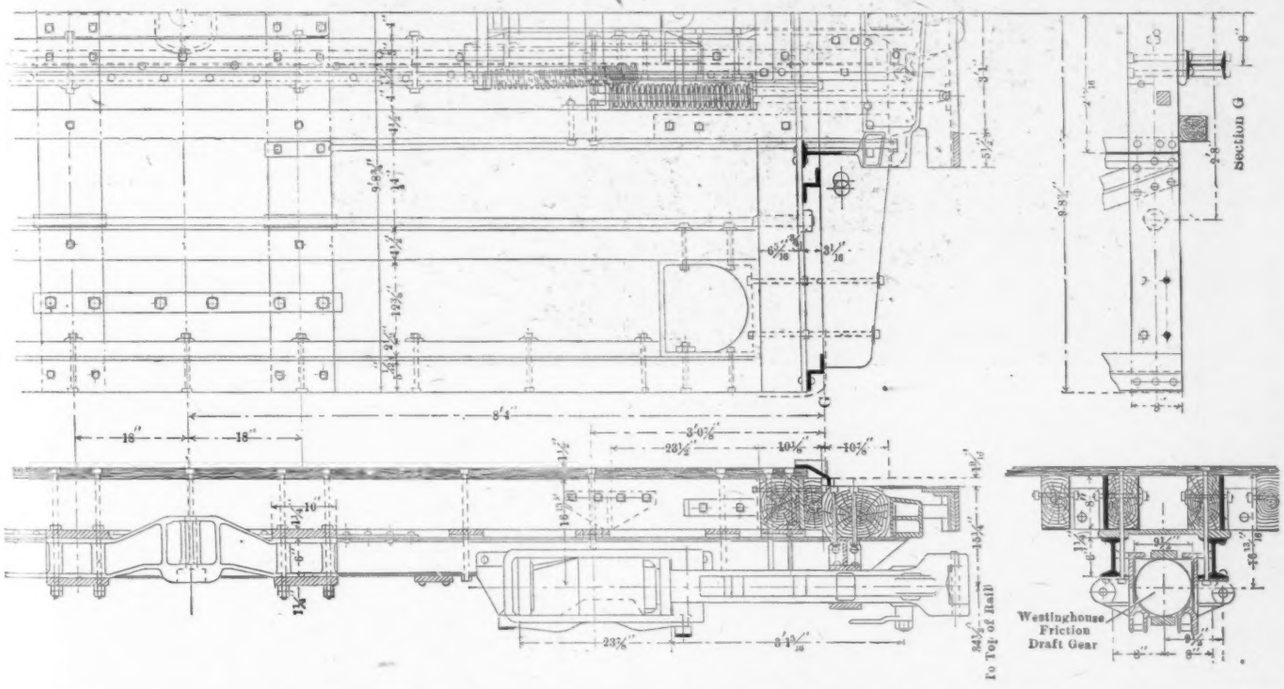

½" Tie Rod upset to ⅝" at each end
Carnegie B–11–25 lbs.
Carnegie Z–10–6.7 lbs.
24" to centre of car
3" x 3½"
3" x 3⅛"
Carnegie Z–10–6.7 lbs.
Carnegie B–11–25 lbs.

REINFORCEMENT OF END CONSTRUCTION OF POSTAL CARS.
PENNSYLVANIA RAILROAD.

angles, to which is connected a vertical plate across the end of the car for a finish. The horizontal plate referred to increases the collision strength of the upper portion of the vestibule. In addition to the I beams, Z bars pass diagonally across the end panels of the car, as indicated in the drawing, these being riveted to the end sill reinforcing plate at the bottom, and secured by angles to the horizontal plate at the top. Other Z bars are built in the corner posts of the car and are riveted to the end sill reinforcing plate at the bottom and the same horizontal plate at the top.

The draft sills of this car are 6-in. I beams extending 13 ins. beyond the inner bolsters. These members receive plates on their upper faces, at each side of both bolsters, and another fits between the two bolsters these plates being riveted to the upper flanges of the I beams. The drawing of the complete framing at the end of the car illustrates the application of the Westinghouse draft gear and the Standard Coupler Company's steel platform, which has been applied to some of these cars which are now in service.

The car itself is similar in its general features to previous construction on this road. Its interior arrangements, however, have been modified to suit recent requirements of the department to produce a combination car, which may be used



REINFORCEMENT OF END CONSTRUCTION OF POSTAL CARS—PENNSYLVANIA RAILROAD.

either entirely for newspaper mail or first-class matter. The floor plan illustrates the large number of cases at one end of the car which are arranged as permanent fittings, but installed in such a way as not to interfere with the use of the car for paper mail when the racks are folded down from the wall.

The end reinforcement is built in accordance with patents issued to Mr. W. F. Kiesel, assistant mechanical engineer of the Pennsylvania Railroad.

Inasmuch as the Interstate Commerce Commission inspectors are very closely watching automatic couplers for the breakage of devices and coupler pin chains, which necessitate going between the cars to make couplings, it seems advisable to direct attention to the importance of one of the primary elements of draft rigging. That is the construction of the rigging so that the coupler cannot travel beyond the standard allowance of motion of 1¾ ins., or 2 ins. at most. If the construction is such that it cannot possibly allow more than that amount of motion to the coupler, it will be impossible for the chains to break under legitimate usage. Perhaps this feature of draft rigging has been overlooked. It should not be longer neglected.

A statement was printed last month giving credit to the shops of the Chicago & Northwestern Railway for the general repairs of 50 locomotives per month in a shop with but 21 pits. Attention has been called to the fact that record had already been made in this journal of general repairs at the rate of more than three engines per pit per month in other shops. In this connection it should be stated that at Altoona 3¼ engines per pit per month are turned out of the erecting shop. This, however, is a shop well equipped with crane service. The performance of the Chicago & Northwestern does not suffer in comparison, because the Chicago shops are not fitted with cranes, the only large crane at those works being in the boiler shop.

AIR OPENINGS UNDER LOCOMOTIVE GRATES.—There seems to be no doubt that there is a direct loss of heat when the air supply is inadequate and that a considerable saving may be accomplished by properly designing the damper openings. In an extract from the report of a committee before the Northwest Railway Club, which appeared on page 102 of our March number, the statement was made that the loss of heat when the air supply is not adequate sometimes reaches 25 per cent., and attention was drawn to the fact that damper openings on some of the newer types of locomotives were entirely too small.

For perfect combustion 8 lbs. of oxygen are required for every pound of hydrogen and 2 2-3 lbs. of oxygen for every pound of carbon. It has been suggested that by staying the firebox with hollow stay bolts with an inside diameter of ⅛ in., perfect combustion may be obtained. It is impossible to get sufficient air through the grates, and air in excessive volumes must not be admitted above the fire bed. The air which it would be possible to get through 1,000 or more hollow stay bolts with ⅛-in. holes might not be sufficient for perfect combustion, but it would furnish enough oxygen to pay for the hollow stay bolts several times over. As the air passes through these stay bolts the risk of burning them is decreased and the expansion of the bolt is reduced, and thus the liability of cracking the sheets is lessened. In addition the exhaust of the locomotive drawing the current of air through the hollow bolts keeps the holes open and affords a means for detecting breakage inside as well as outside of the firebox. The bolts are rolled hollow and the strength is thus increased and the bolt is more flexible.

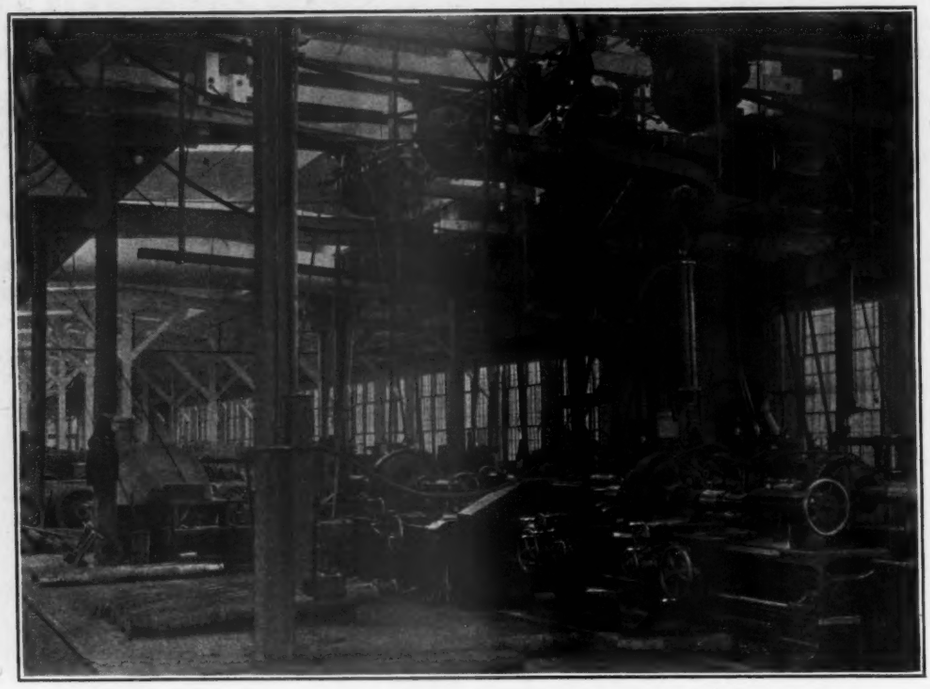
ANGUS LOCOMOTIVE & CAR SHOPS, MONTREAL.

CANADIAN PACIFIC RAILWAY.

V.

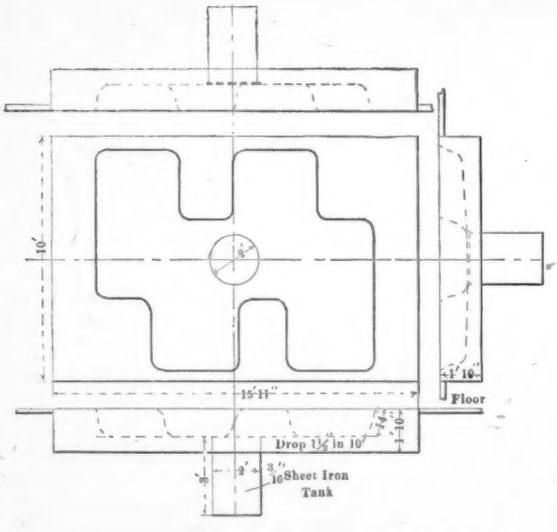
(*For previous article see page* 75.)

TRUCK SHOP.—This shop was shown in section in January, page 2. One of the accompanying engravings shows the west end with the location of machinery. The portion of the building not shown in this partial plan contains two tracks for passenger car trucks at the south side of the building and two for freight trucks at the north side, the work on freight trucks being facilitated by shallow pits outside the rails, enabling the men to get at the nuts on the side frames. Four men constitute a gang, and on the day of the writer's visit 28 trucks for 60,000-lb. cars had been completely assembled at 2:30 p. m. The rate of working approximates four trucks per hour. These trucks had diamond frames and Simplex bolsters. At the west end of the shop, material is brought to the machines on two short tracks reaching the axle lathes and wheel borers. The machinery is enumerated in the accompanying list. Each of the seven machines running, during the writer's visit, was turning out twelve 4¼ by 8-in. axles per day. The journals are also "rolled" in the lathes. The lathe foundations are of concrete, with an irregular depression, or basin, 14 ins. deep, having at the center a submerged sheet iron tank, 2 ft. in diameter by 3 ft. deep, to catch the drainage from the tools. The foundations themselves are 22 ins. deep. They are provided for all of the axle lathes in the shop. Storage for axles is provided near the axle lathes, and storage for wheels in the two spaces indicated; one is for 144 and the other for 222 wheels. The wheel presses are numbered 55 and 56 on this plan, and are located at the ends of the tracks, which reach to the opposite end of the building, these being the central two of the four tracks. The wheel presses are provided with Crosby recording gauges, in order to check the pressures used in pressing on the wheels. This shop is arranged for progressive work, the work advancing to completion at the east end, for delivery to the erecting shops. Every operation in the truck shop is on piecework.

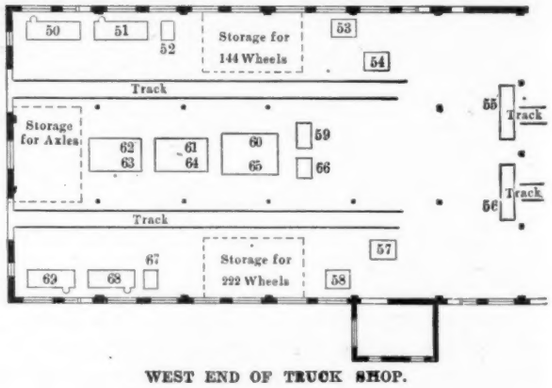


INTERIOR OF TRUCK SHOP.

CAR MACHINE SHOP.—The plan of this building shows three longitudinal tracks, crossed by one transverse track with turntables. A section of the shop was shown in January, page 3. It provides for the machine work and bolt work, and is a manufacturing establishment. A very large amount of bolt



CONCRETE FOUNDATIONS FOR AXLE LATHES.

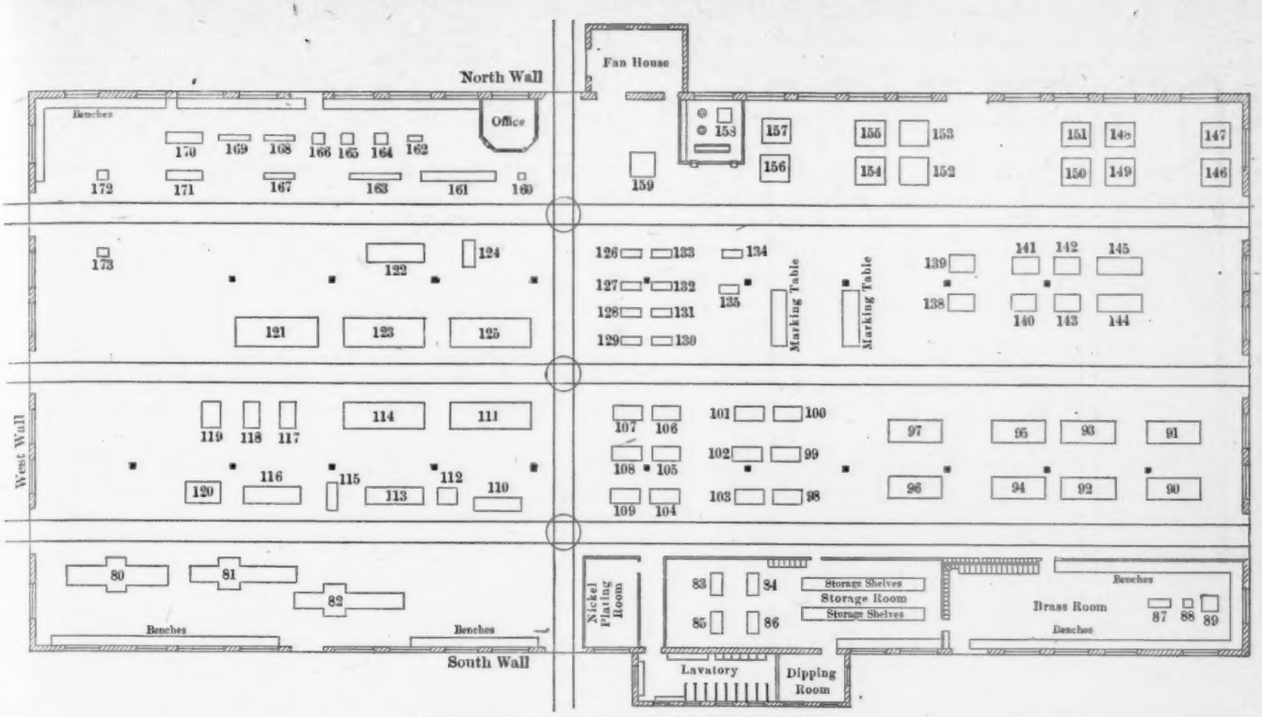


WEST END OF TRUCK SHOP.

LIST OF TOOLS.

TRUCK SHOP.

No.	Name and Maker.	Motor H.P.
50.	Axle lathe, J. Bertram & Sons	20
51.	Axle lathe, J. Bertram & Sons	
52.	Water emery wheel	
53.	Car wheel borer, J. Bertram & Sons	15
54.	Car wheel borer, McKechnie & Bertram	
55.	Wheel, press, Hamilton Machine Tool Company	5
56.	Wheel press, C. P. R.	5
57.	Car wheel borer, Niles Tool Works	15
58.	Car wheel borer, Niles Tool Works	
59.	5 ft. grindstone, Pond Machine Tool Company	
60.	Axle lathe, Niles Tool Works	30
61.	Axle lathe, J. Bertram & Sons	
62.	Axle lathe, J. Bertram & Sons	
63.	Axle lathe, Niles Tool Works	
64.	Axle lathe, J. Bertram & Sons	30
65.	Axle lathe, Niles Tool Works	
66.	3 ft. wet emery wheel, Bridgeport Emery Wheel Company	
67.	Emery wheel	
68.	Axle lathe, McKechnie & Bertram	15
69.	Axle lathe, J. Bertram & Sons	
—.	Wheel press	7½



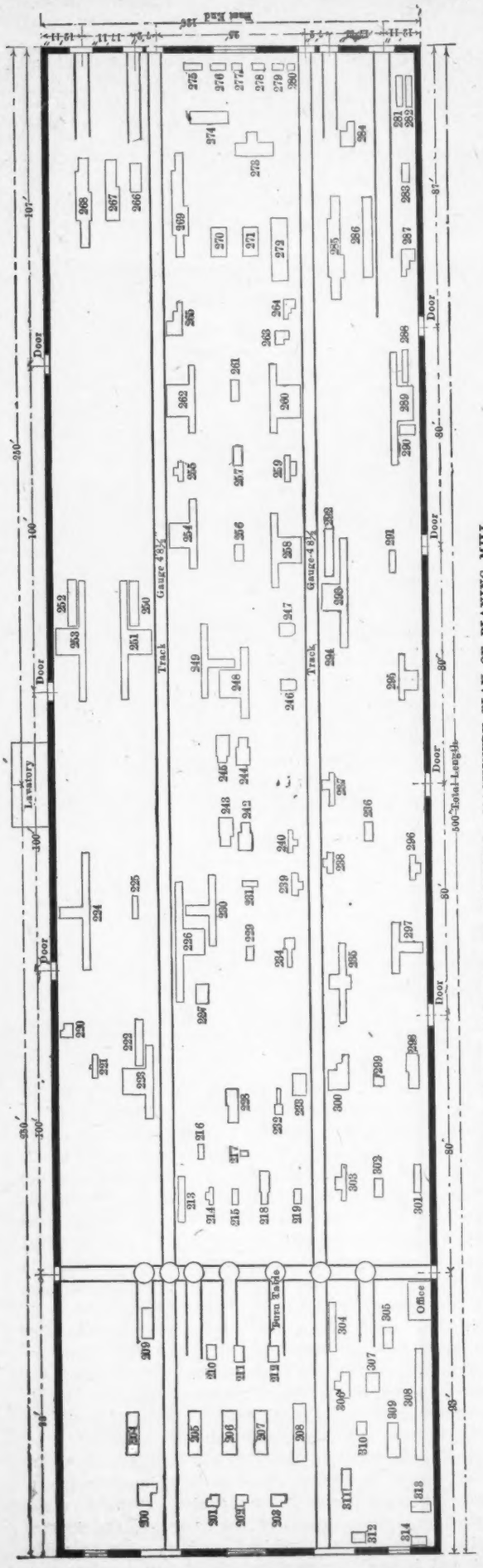
MACHINERY PLAN OF CAR MACHINE SHOP.

CAR MACHINE SHOP.

No.	Name and Maker.	Motor H.P.
80.	Double-headed planer, 48 ins. x 48 ins. x 12 ft., Mark Flather Planer Company	20
81.	Double-headed planer, 36 ins. x 36 ins. x 10 ft., McGregor & Gourley	7½
82.	Single headed planer, 30 ins. x 30 ins. x 10 ft., McGregor & Gourley	7½
83.	Double buffer	10
84.	Double buffer	
85.	Double buffer	
86.	Double buffer	
87.	¾-in. turret lathe, Bertram & Sons	5
88.	16-in. sliding head drill press, Hamilton Machine Tool Company	
89.	Miller, Smith & Coventry	30
90.	6-spindle arch bar drill, Niles Tool Works	
91.	6-spindle arch bar drill, Bertram & Sons	
92.	6-spindle drill	
93.	6-spindle arch bar drill, Bertram & Sons	
94.	6-spindle drill, Bertram & Sons	
95.	6-spindle drill, Bertram & Sons	
96.	6-spindle drill, Bertram & Sons	
97.	6-spindle drill, Bertram & Sons	
98.	32-in. vertical drill, Bertram & Sons	15
99.	28-in. vertical drill, Cincinnati Machine Tool Company	
100.	25-in. vertical drill, Bertram & Sons	
101.	28-in. vertical drill, Cincinnati Machine Tool Company	
102.	28-in. vertical drill, Cincinnati Machine Tool Company	
103.	28-in. vertical drill, McGregor & Gourley	
104.	26-in. vertical drill, Prentice Bros.	
105.	20-in. vertical drill, Prentiss	
106.	20-in. vertical drill	
107.	30-in vertical drill	
108.	26-in. vertical drill, Bertram & Sons	
109.	25-in. vertical drill, Bertram & Sons	
110.	Bolster drill	30
111.	54-in. wheel lathe, Bertram & Sons	
112.	12-in. double emery wheel, C. P. R.	
113.	Journal lathe, McKechnie & Bertram	
114.	54-in. wheel lathe, Bertram & Sons	
115.	5 ft. x 8 in. grindstone, Pond Machine Tool Company	
116.	24-in. double head traverse shaper, Cincinnati Shaper Company	
117.	14-in. shaper	
118.	18-in. shaper	
119.	24-in. shaper, Mark Flather	
120.	11-in. slotter, McKechnie & Bertram	
121.	42-in. wheel lathe, Pond Machine Tool Company	20
122.	Engine lathe, 15 ins. x 7 ft., Guelph Machine Tool Company	15
123.	54-in. wheel lathe, Bertram & Sons	
124.	5 ft. x 8 ins. grindstone, Pond Machine Tool Company	
125.	54-in. wheel lathe, Bertram & Sons	
126.	6-in. small vertical drill, C. P. R.	5
127.	6-in. small vertical drill, C. P. R.	
128.	6-in. small vertical drill, C. P. R.	
129.	6-in. small vertical drill, C. P. R.	
130.	6-in. small vertical drill, C. P. R.	
131.	6-in. small vertical drill, C. P. R.	
132.	6-in. small vertical drill, C. P. R.	
133.	8-in. small vertical drill, W. F. & T. Barnes Company	
134.	16-in. sliding head drill press, Hamilton Machine Tool Company	
135.	16-in. sliding head drill press, Hamilton Machine Tool Company	
138.	¾-in. 6-spindle nut tapper, Acme Machine Company	10
139.	⅞-in. 6-spindle nut tapper, Acme Machine Company	
140.	1⅛-in. 6-spindle nut tapper, Acme Machine Company	
141.	1-in. 6-spindle nut tapper, Acme Machine Company	
142.	1⅛-in. 4-spindle nut tapper	
143.	1-in. 4-spindle nut tapper	
144.	1⅛-in. 6-spindle nut tapper	
145.	1⅛-in. 6-spindle nut tapper	
146.	1⅝-in. double bolt threader	10
147.	1½-in. double bolt threader	
148.	1½-in. double bolt threader, A. R. Williams Machine Company	
149.	1½-in. double bolt threader	
150.	1½-in. triple bolt threader, Bertram & Sons	
151.	1½-in. triple bolt threader, Bertram & Sons	
152.	1½-in. double bolt threader, National Machine Company	10
153.	2-in. triple bolt threader, National Machine Company	
154.	1-in. double bolt threader	
155.	1⅛-in. double bolt threader, National Machine Company	
156.	2-in. triple bolt threader, Bertram & Sons	
157.	2-in. triple bolt threader, Bertram & Sons	
158.	Drill grinder, Washburn Shops	
159.	Universal milling machine, No. 3, Cincinnati Milling Machine Company	
160.	Universal tool grinder, Cincinnati Milling Machine Company	20
161.	Engine lathe, 30 ins. x 12 ft., Lodge & Shipley	
162.	8-in. vertical drill	
163.	Engine lathe, 24 ins. x 6 ft. 10 ins., Bertram & Sons	
164.	20-in. wet emery wheel, No. 3, Bridgeport Emery Wheel Company	
165.	8-in. vertical drill	
166.	Key seater, No. 1, W. P. Davis Machine Company	
167.	Engine lathe, 20 ins. x 5 ft. 6 ins., Bertram & Sons	
168.	Engine lathe, 16 ins. x 7 ft. 3 ins., McGregor & Gourley	
169.	Engine lathe, 18 ins. x 6 ft. 3 ins., Lodge & Shipley	
170.	Engine lathe, 17 ins. x 5 ft.	
171.	Engine lathe, 15 ins. x 5 ft., Prentice Bros.	
172.	12-in. double emery wheel, Diamond Machine Company	
173.	12-in. double emery wheel, Diamond Machine Company	
	Car haul	10
	Car haul	10

and nut work is done here, the bolts being received from the car portion of the blacksmith shop in iron boxes, in which they are allowed to cool from the forging machines before reaching the machine shop. These boxes are handled by air hoists. The floor is clear of material. Bolts and nuts are made here for the entire system, including all but the finished bolts for the locomotive department. This shop turns out 20 pairs of passenger wheels per day, besides drilling brake levers, passenger platforms, and arch bars. Six-spindle Bertram drills each turn out 75 arch bars per day, the plan being followed, as far as possible, of concentrating the work of a given kind here for the entire system. This shop handles work as heavy as truck equalizers. The southeast corner of the building provides for the brass room, nickel-plating room and store room for the hardware for cars. This building is heated from a fan at the north wall. The location of the office and tool room are shown in the plan.

FREIGHT CAR ERECTING SHOP.—This building was shown in section on page 3. It is strictly a manufacturing department. It contains six tracks, with three air-hoist traveling cranes over each bay of three tracks at the east end, and is provided with a few special machines, such as circular saws. The west end is used for painting. This shop is also on a piecework basis throughout, and the pace of the workmen is



ANGUS SHOPS, CANADIAN PACIFIC RAILWAY, AT MONTREAL.—MACHINERY PLAN OF PLANING MILL.

PLANING MILL.

No.	Name and Maker.	Motor H.P.
200.	No. 1 Greenlee Auto cut-off saw	20
201.	No. 1 Greenlee Auto cut-off saw	
202.	No. 1 Greenlee Auto cut-off saw	
203.	No. 1 Greenlee Auto cut-off saw	40
204.	No. 46 Berlin planer and double matcher	40
205.	No. 46 Berlin planer and double matcher	30
206.	No. 44 Berlin planer and double matcher	
207.	Bertram large 4-headed matcher and dimension planer, 6 ins. x 24 ins.	30
208.	Fay large 4-headed matcher, 6 ins. x 24 ins.	20
209.	No. 1½ Greenlee S. F. rip saw set with collar 4 inches long	50
210.	No. 1½ Greenlee S. F. rip saw set with collar 4 inches long	
211.	No. 1½ Greenlee S. F. rip saw set with collar 4 inches long	
212.	Greenlee S. F. rip saw, 30-in saw	
213.	C. P. R. swing saw, 18-in. saw	30
214.	No. 98 Woods & Co. improved jointing and facing machine or buzz planer	
215.	No. 3 McGregor, Gourley & Co. self-feed rip saw	
216.	McGregor, Gourley & Co. new improved rip saw, 30-in. saw	
217.	Bertram horizontal borer, 12 ins. thick, 3⅛-in. hole	10
218.	McKechnie & Bertram large horizontal tenoning machine, 9 in.	
219.	No. 3 McGregor, Gourley & Co. band saw	
220.	No. 5 McGregor, Gourley & Co. large band resaw	15
221.	Vertical car sill end tenoning machine, 9 ins. x 12 ins. thick, MeKechnie & Bertram	20
222.	Swing saw, 18-in., C. P. R.	
223.	Greenlee extra range heavy car boring machine, 12 ft. table	
224.	No. 3 Greenlee extra range heavy Auto car gainer, 40-ft. table	15
225.	No. 4 Greenlee Auto vertical car sill tenoner	15
226.	No. 14 Greenlee std. heavy vertical hollow chisel mortiser, 40-ft. table	20
227.	No. 58 Fay band saw	
228.	No. 00 McGregor, Gourley & Co. outside moulding machine	10
229.	No. 00 Fay Patent band saw, 36-in. wheels	20
230.	Bertram horizontal gainer, 14 ins. thick x 24 ins. wide	
231.	Bertram single horizontal boring machine, 2-in.	
232.	McGregor, Gourley & Co. double-headed shaper	10
233.	Greenlee 3-spindle medium heavy vertical boring machine	
234.	McGregor, Gourley & Co. double-headed shaper	20
235.	Bertram hollow chisel mortiser, 2½-in.	
236.	McGregor, Gourley & Co. rip saw	40
237.	Fay vertical gainer, checks 2 ins. deep by 3 ins. wide	
238.	Fay 3-spindle boring machine, bores 2½ ins., 12 ins. deep	
239.	Greenlee std. heavy 3-spindle vertical car boring machine	
240.	Greenlee heavy single-spindle horizontal boring machine	
242.	McKechnie & Bertram large horizontal 9-in. tenoning machine	40
243.	No. 5 Greenlee heavy Universal horizontal car tenoner	
244.	McKechnie & Bertram large horizontal tenoning machine	
245.	No. 5 Greenlee heavy Univeral horizontal car tenoner	
246.	No. 6 Fay car 72-in. mortiser and borer	10
247.	No. 6. Fay car 72-in. mortiser and borer	
248.	No. 14 Greenlee std. heavy vertical hollow chisel mortiser 12-in. table	
249.	No. 3 Greenlee extra range heavy auto car gainer	15
250.	Swing saw, 18-in., C. P. R.	20
251.	Greenlee extra range heavy car boring machine, 40-ft. table.	
252.	Swing saw, 18-in., C. P. R.	20
253.	Greenlee extra range heavy car boring machine, 40-ft. table.	
254.	Bertram horizontal gainer, gains timber 2 ins. x 3 ins. wide, 16 ins. across	15
255.	Greenlee std. heavy 3-spindle vertical car boring machine	
256.	No. 2 Fay improved std. ripping saw	15
257.	No. 2 Fay improved ripping saw	15
258.	Greenlee 5-spindle boring machine	20
259.	Greenlee std. heavy 3-spindle vertical car boring machine	
260.	No. 14 Greenlee std. heavy vertical hollow chisel mortiser	15
261.	No. 3 Fay large size car ripping saw	20
262.	Greenlee extra range heavy car boring machine	20
263.	No. 2 Greenlee Auto cut-off saw	15
264.	No. 5 Greenlee vertical heavy Auto cut-off saw, to cut timber up to 14 ins. square	
265.	No. 5 Greenlee vertical heavy Auto cut-off saw, to cut timber up to 14 ins. square	15
266.	No. 3 Greenlee rip saw, takes 30-in. saw and rips 18 ins. wide	20
267.	No. 6 Fay outside moulder	30
268.	No. 8 Berlin planer and sizer	50
269.	No. 8 Berlin planer and sizer	50
270.	No. 3 Greenlee rip saw	20
271.	No. 3 Greenlee rip saw	20
272.	No. 24 Berlin planer, matcher	30
273.	Fay variety wood worker or buzz planer	5
274.	McGregor, Gourley & Co. Auto band saw filer	10
275.	No. 1 Fay Auto knife grinder	
276.	Knife grinder	
277.	C. P. R. emery wheel	
278.	Egan Auto knife grinder	
279.	Emery wheel	
280.	Circular saw sharpener	
281.	Pond portable grindstone, 72 ins.	
282.	Pond portable grindstone, 72 ins.	
283.	Bertram large rip saw, 36 ins. saw	15
284.	No. 6 Greenlee vertical heavy Auto cut-off saw	15
285.	Fay 4-head dimension planer, planes 12 ins. deep, 16 ins. wide, 4 sides	40
286.	Cant Gourley 4-headed matcher and dimension planer, planes 6 ins. thick, 24 ins. wide	20
287.	Bertram large butting saw, 36 ins. saw	15
288.	Iron frame swing saw, 18 ins. saw, C. P. R.	20
289.	Greenlee 5-spindle boring machine	
290.	Bertram horizontal gainer, gains 2 ins. deep, 3 ins. wide, 16 ins. across	
291.	McKechnie & Bertram vertical end tenoning machine, 9 ins. x 12 ins.	30
292.	Iron frame swing saw, 18 ins. saw, C. P. R.	15
293.	Greenlee big hollow chisel sill mortiser machine, 8 in. deep, 2 in. chisel	
294.	3 spindle boring machine, C. P. R.	
295.	Hollow chisel mortising and boring machine, C. P. R.	15
296.	Greenlee 3-spindle medium heavy vertical boring machine	15
297.	Gainer, gains 2 ins. thick, 3 ins. wide, 16 ins. face Fay & Egan	
298.	McGregor, Gourley & Co. 4-headed outside moulder	20

No.	Name and Maker.	Motor H.P.
299.	No. 1½ McGregor, Gourley & Co. shaping machine	15
300.	No. 3 Greenlee vertical heavy Auto cut-off saw and gainer	
301.	McGregor Gourley & Co. dimension saw	15
302.	McGregor, Gourley & Co. band saw, 36 in. wheel	
303.	Fay auto vertical cut-off saw	
304.	McGregor, Gourley & Co. swing saw, 32 in. saw	12
305.	Rip saw, 30 in. saw, C. P. R.	
306.	McGregor, Gourley & Co. buzz planer	
307.	Cowan & Co. small rip saw, 14 in. saw	
308.	McGregor, Gourley & Co. dimension planer, planes 6 ins. x 24 ins.	
309.	McGregor, Gourley & Co. 4-headed outside moulder	
310.	Bertram surface planer, planes 6 ins. thick x 24 ins. wide	30
311.	McGregor, Gourley & Co. small rip saw	
312.	Chain saw mortiser	
313.	Small sash door mortiser	10
314.	McKechnie & Bertram light tenoning machine tenons for sash and doors	

a remarkable one for any shop. At the time of the writer's visit sixteen 60,000-lb. box cars were being turned out per day. At the west end of the building motor-driven winches are located, for hauling out the cars completed each day. This building, like all the rest, is well provided with automatic sprinkers for fire protection.

Planing Mill.—This building is 500 ft. long by 125 ft. wide, and the machinery is divided into two parts; one for preparing material for building new freight cars, and the other for preparing material for building new passenger cars, store orders and repair work. These two departments are entirely separate. All the heavy timber comes in at the east end of the mill (at the right in the floor plan), where there are placed for the freight car department two large timber planers, one inside moulder, two large self-feed rip saws. The north side of the mill (upper part of the plan) is used exclusively for the sills and long timbers, and after the sills have been run through the planer they are butted off and then passed over to the end tenoning machine, and then to two five-spindle vertical boring machines with 40-ft. travelling tables, and from this machine to a gaining machine, and from the gaining machine they are placed on a lorry and run into the erecting shop. On this same side there is also a hollow chisel mortising machine with a 40-ft. travelling table for mortising plates and ridge poles.

The center of the mill is used for getting out short material for new freight cars, such as end sills, posts and carlines, and after they are run through the planers they are next passed to large butting saws, and then to mortising and boring machines, as the case may be, and when finished the pieces are placed upon roller-bearing lorries and transferred into the erecting shop.

Material for passenger cars, store orders and repair work is handled in the same manner as described for the freight cars. It is taken in at the east end of the mill, where there are two large timber planers and one large matcher or sizer, and then passed on to boring, mortising and graining machines until finished.

At the west end of the mill there is a cross track with turntables, where all lighter material is brought in and laid down to the planers and matchers. For the freight car side there are two large double matchers and planers and one single matcher. For the passenger car side there are two matchers and planers, and at the rear of all these planers there is an automatic cut-off saw for each planer to cut off sheathing, etc., after it has been run through. In the west end of the shop there are also two sets of machinery for getting out the lighter work for the interior finish and repairs to passenger cars.

All the machines in this mill are motor-driven; the larger machines by independent motors and the lighter machines in

(1) Exterior portions of shavings exhaust system. (2) Tenoning machine in planing mill. (3) One of the planers, planing mill. (4) Shavings exhaust applied to a gaining machine.

TESTS MADE ON MOTORS DRIVING FANS IN PLANING MILL, CABINET SHOP, AND SHAVINGS TOWER.

(Speeds observed with an Indicating Tacheometer.)

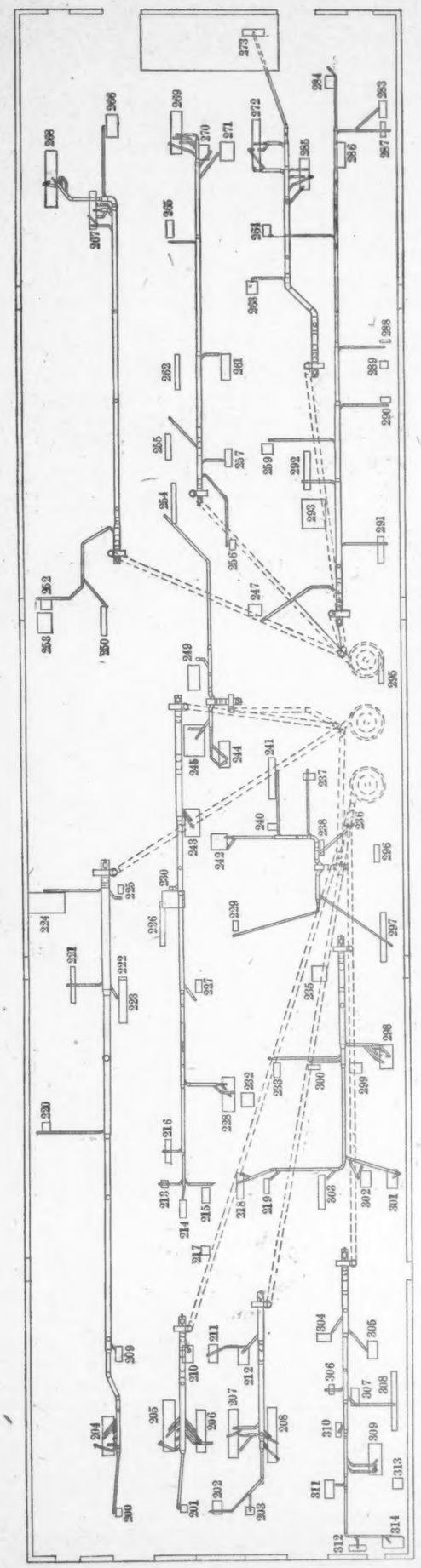
Fan.	Vacuum—At fan. inches.	Vacuum—At end of pipe. inches.	Speed of fan—actual.	Speed of motor—actual.	Input. h.p.	Rated h.p of motor.
A	4 13-16	3 1-16	820	840	30.1	30
B	6¼	5⅝	830	890	30.3	30
C	4⅞	3⅝	815	860	23.2	30
D	4⅝	3¼	720	860	19.4	30
E	5	2½	880	885	18.1	20
F	4 11-16	3	725	900	19.6	30
G	5⅝	3 1-16	805	880	26.6	30
H	4⅞	3⅞	810	900	26.7	30
I	5⅛	2⅞	880	880	13.9	20
J	4⅝	3 1-16	820	880	19.8	30
K	5⅛	3¾	805	885	30.0	30
L	4½	3¾	800	875	20.5	30
M	5	4⅛	760	890	13.1	20
N	5¼	4 3-16	665	890	25.8	30
O	4½	3	800	514	27.4	30
P	11½	4¼	1,720	880	26.4	30
Q	7¾	7	1,100	900	22.5	20

Remarks.

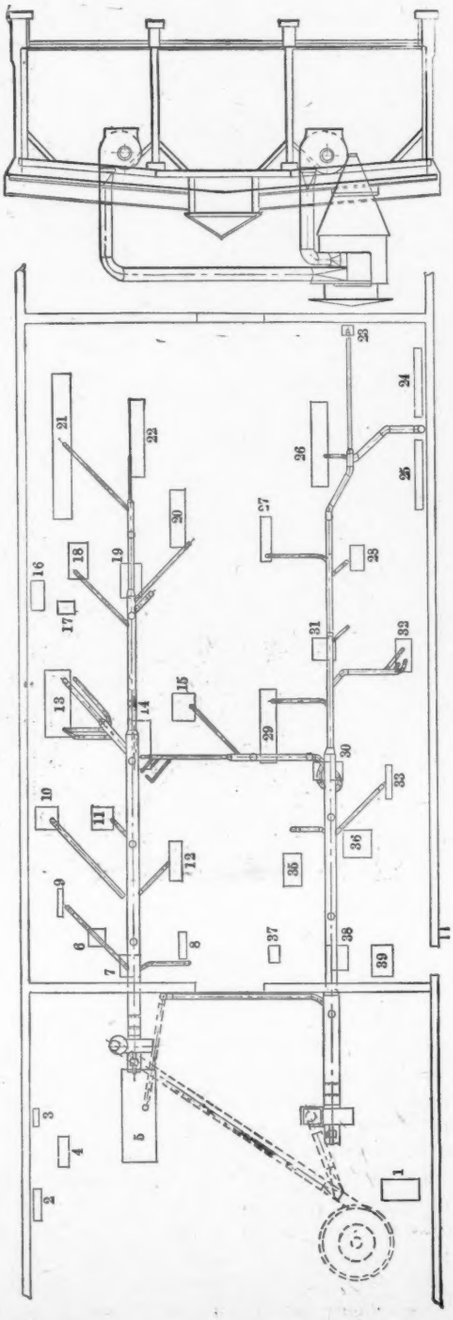
Fans A to L are in planing mill; M and N in cabinet shop, and O to Q in the shavings tower.

Shutting off two inlets on pipes connected to fan K made a decrease of 6 h.p. in motor input.

20-h.p. motor was found to take ½ h.p. running light with belt off, and 30-h.p. motor, 1.9 h.p.



PLAN OF SHAVINGS EXHAUST SYSTEM APPLIED TO PLANING MILL.



PLAN OF SHAVINGS EXHAUST SYSTEM APPLIED TO THE CABINET SHOP.

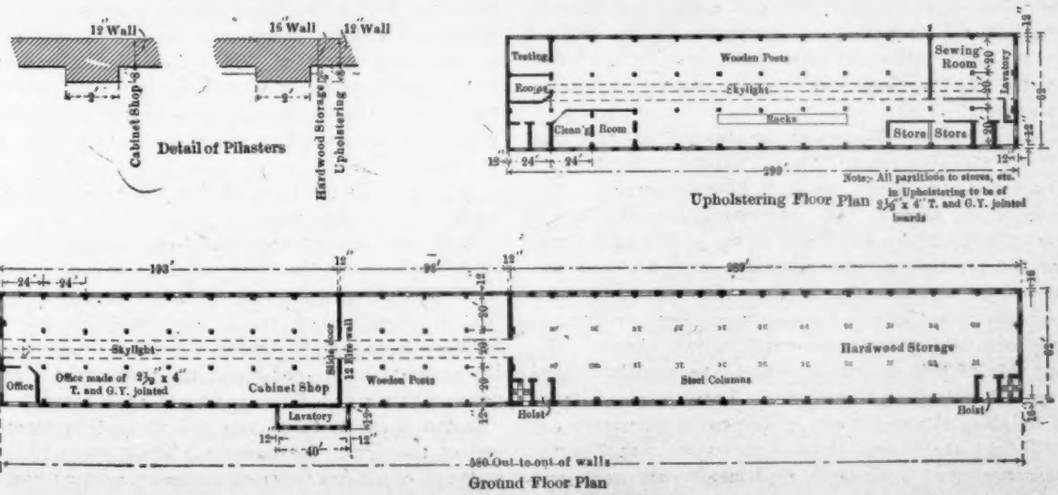
CABINET SHOP.

No.	Name and Maker.	Motor H.P.
1.	Double combination glue spreader	2
2.	Window blind mortiser, Jno. Bertram & Sons	5
3.	Window blind slot mortiser, McGregor, Gourley & Co.	
4.	Boults Carver, McGregor, Gourley & Co.	
5.	Royal Invincible sander, Berlin Machine Works	40
6.	Jig saw, C. P. R. make	7½
7.	Sash and door mortiser, Jno. Bertram & Sons	
8.	No. 3 band saw, McGregor, Gourley & Co.	
9.	Chain mortiser, No. 66, New Britain	5
10.	Sash sticker, McGregor, Gourley & Co.	10
11.	Finishing saw, mitering work, Herbert Baker & Co.	
12.	Band saw, 36-in. wheel, McGregor, Gourley & Co.	
13.	Double tenoning machine, 10-in. to 6 ft. 6 ins., McGregor, Gourley & Co.	15
14.	Four-headed inside moulder, McKechnie & Bertram	20
15.	Pony planer, J. A. Fay & Co.	
16.	Grindstone, 72-in., Pond Machine Tool Company	20
17.	Emery wheel, C. P. R.	
18.	Dimension saw table, 16 ins. wide, 3 ins. thick, McGregor & Gourley Company	
19.	Double-headed 16-in. saw, McGregor & Gourley Company	
20.	Perfection buzz planer and jointer, McGregor & Gourley Company	
21.	Dimension planer, sizing and straightening, McGregor & Gourley Company	15
22.	Swing saw, 16 in., C. P. R.	5
23.	Feed rod machine, ¼ to 1½ in., McGregor & Gourley Company	5
24.	24-in. wood lathe, McGregor & Gourley Company	5
25.	20-in. wood lathe, Smith & Coventry	
26.	Swing saw, 16-in., C. P. R.	5
27.	Universal wood worker, Egan & Co.	15
28.	Rip saw, 12-in., McGregor & Gourley Company	
29.	Panel planer, McGregor & Gourley Company	20
30.	Tenoning machine, McGregor & Gourley Company	
31.	Rip and cross cut saw, 14-in., McGregor & Gourley Company.	
32.	3-sided inside moulder, McGregor & Gourley Company	15
33.	Chain mortiser, No. 66, New Britain Machine Works	
34.	Chain grinder, New Britain Machine Works	
35.	Shaping machine, McGregor & Gourley Company	10
36.	Shaping machine, McGregor & Gourley Company	
37.	Single spindle boring machine, McGregor & Gourley Company	10
38.	Friezing machine, J. A. Fay & Co.	
39.	2-spindle carver, Blouts	

groups. All of the motors are placed overhead, with the exception of the large ones which run the planers, so as to allow plenty of floor space.

At the east end of the mill is an elevated extension platform which is used for a template and saw filing room. In the

INTERIOR VIEW OF PLANING MILL.

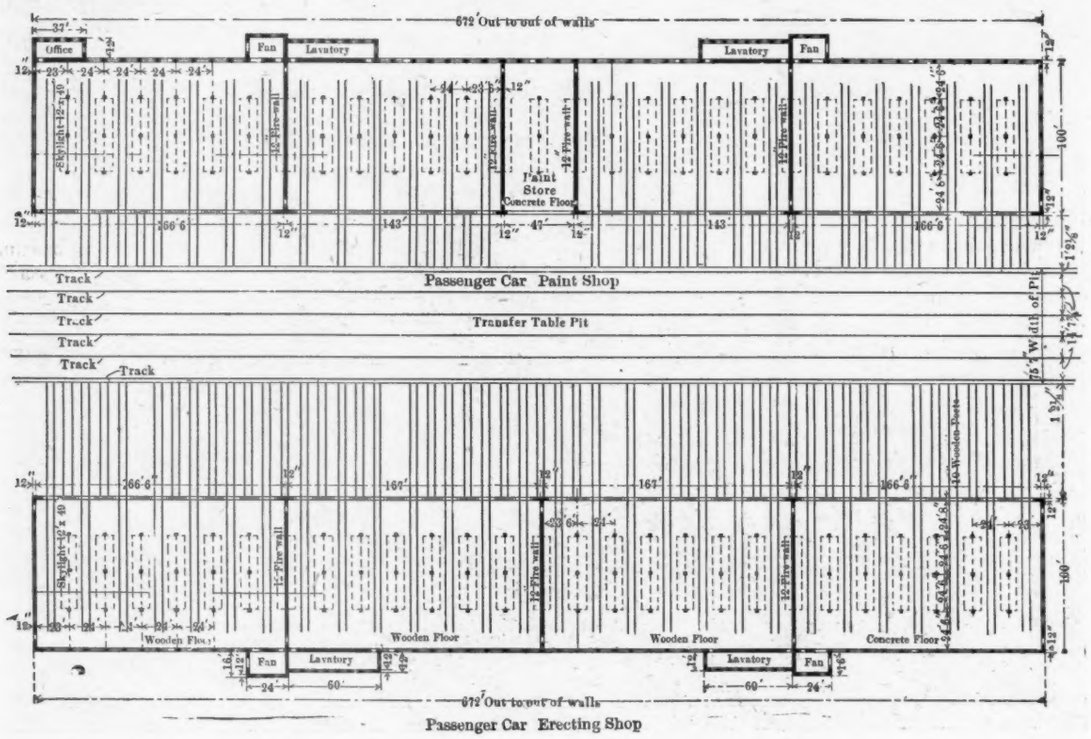


FLOOR PLANS OF CABINET SHOP.

saw filing room are four automatic knife grinders, one surface grinder for truing and sizing up blank steel for shaper and sticker knives, two automatic circular saw filers, two automatic band saw filers, one for small band saws and one for large band saws, and all the necessary tools for hammering and straightening circular saws, and also two emery wheel stands.

The number of men employed on the passenger side of the mill averages 100, and the number of men in the saw filing room is five. The number of men on the freight car side averages 75. The expected output for freight cars is twenty-five per day, and about fifteen passenger cars per month.

CABINET SHOP.—This shop is situated on the north side of one of the passenger car shops, with a large room for dry lumber at the east end. In the center is placed the wood-working machinery for cabinet work, and cabinet-makers' benches in the west end. This building is 62 ft. wide by 581 ft. long. The lumber is taken from the dry kilns, which are situated east of the lumber room, and taken into the lumber room and stored until required. From the lumber room it is taken to the wood-working machinery in the center, and from



PLAN OF PASSENGER CAR SHOPS, SHOWING TRANSFER TABLE.

there to the cabinet-makers. The cabinet shop is equipped with a double set of light machinery for getting out interior finish for all classes of passenger equipment. The cabinet shop is also equipped with eight large presses for veneer work. Cabinet-makers are provided with double standard benches with tail screws.

PASSENGER CAR SHOPS.—There are two passenger car shops. Each is 100 ft. wide by 672 ft. long. There are twenty-eight tracks in each shop, making a total of fifty-six tracks. The north passenger car shop is used exclusively for erecting of new passenger cars. There are five sections in this shop; four sections for the erection of new passenger cars and one section which is used at present as a paint store room and auxiliary store room. One side of the section is used for storage of paints and oils. All stencils are made in this room.

The other side of this section is used as an auxiliary store room, for car trimmings and hardware. There is also a large store room building situated south of the south passenger car shop controlled by the stores department, where supplies for both the passenger and locomotive departments are kept, and the idea of having the small auxiliary store in the north passenger car shops is so as to facilitate the work and avoid having to go over to the large store room for small quantities The floor in the paint store room and auxiliary store room is of concrete.

Both the north and south passenger car shops are well lighted and ventilated. There are arc lights in each section of these two shops, and also incandescent lights between the tracks, so that the men working on cars may be enabled to do their work under all conditions. Portable electric light extensions are furnished the men when working inside cars, and these extensions are connected to special plugs which are located on posts, and are made long enough so that the men working inside the cars may move around with them. There is a switch box in each section, so that the arc lights and incandescent lights are operated independently of each other. The incandescent lights which are placed between the tracks may be operated individually, there being separate switches for each row of lights.

The south passenger car shop is composed of four sections, and all repairing of passenger cars is done in this shop. One section in this shop is used exclusively as a "wash room," where the cars are placed upon being taken into the shop and stripped of doors, sashes and trimmings, and then immediately washed. Part of another section is used as a varnish room, where all sashes, doors and fittings belonging to cars are painted and varnished. This shop is fitted up similar to the north passenger car shop as regards ventilation, lighting, lavatories, etc. The skylights in both the north and south passenger car shops are so placed as to throw the light between the cars.

A 75-ft. transfer table serves the passenger car shops, operated by a 50-h.p. motor.

Each track of the south passenger car shop extends outside of the shop sufficiently to hold a passenger car for storage until such time as it can be taken into the shop, making a total of twenty-eight tracks for storage of cars. In addition to these twenty-eight tracks, there are a number of tracks at the east end of the passenger car shops, where cars are stored until such time as there is vacant shop room.

Before a car is taken into the shops it is placed at the east end of the north passenger car shop, when it is immediately stripped of all upholstering material, such as seats, seat backs, mattresses, pillows and spring beds, and after this equipment is removed the car is then placed in the "wash room" in the

south passenger car shop, where it is washed and the heating apparatus tested to ascertain defects. This being all attended to, the car is then pulled out of the "wash room" and placed in another section, where all necessary repairs are made. When the repairs have been completed, the car is varnished and trimmed, and is then set outside of the shop and reported for service, and another car is taken in.

Shavings Exhaust System.—This system uses Sturtevant apparatus, and was installed by the C. H. Gifford Company, of Philadelphia. It is applied to the planing mill and the cabinet shop, the location of the piping and the fans being indicated. In the large engraving showing the conduits for the planing mill those above the roof are shown in dotted lines This also applies to the cabinet shop. One of the photographs shows the conduits leading from the planing mill and the cabinet shop to the top of a shaving storage vault at the power house. The view of the interior of the planing mill illustrates the conduits inside of that building, and the three smaller photographs of the interior of the mill show the application of the system to a planer, a tenoning machine and a gaining machine. This system employs 17 fans of from 50 to 90 ins. in diameter, and running from 665 to 1,700 revolutions per minute, the maximum speeds of the fans in the planing mill being 880 ft. per minute. This dust collector system works admirably, and is designed to use large fans running at relatively slow speeds. The purpose was to instal a plant which would reduce to a minimum the constant charge for power, and the table of the performance, taken in a test made December 7th, 1904, shows the power required for this system. The longest run of conduit is about 700 ft., and the dimensions of the piping were selected with a view of rendering the power as efficient as possible. Space does not permit of the detailed description which this feature of the plant merits. In deciding upon the capacity for the equipment computations were made upon the difference between finished and rough dimensions of timber in a 30-ton box car. This amounts to 860 ft. board measure, or 72½ cu. ft. per car, and this volume will fill two or three times that space when put into the form of shavings and sawdust.

REPORT OF COMMITTEE ON POWER.

ROCK ISLAND COMPANY.

Independent Motor Cars.

(*For previous article see page* 84.)

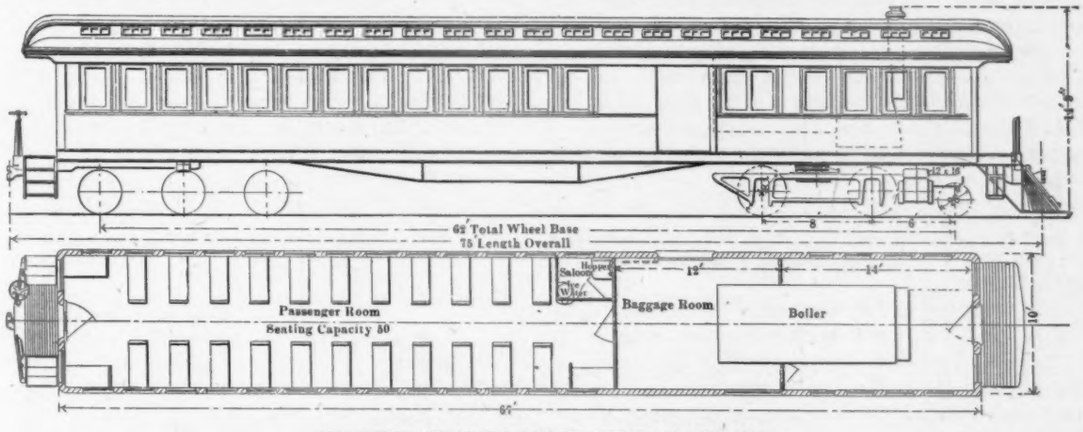
In the last six or seven years a number of composite motor cars have been built in this country and abroad for operating branch lines of steam railways where the travel is light and where the service requires the movement of about one carload of passengers at long or short intervals.

In many instances one car will afford accommodations enough at any one time for all the available business on branch lines. In such locations it does not pay to run a regular passenger train, as the wages of engineer, fireman and train crew, together with the general expenses of running such a train, are out of all proportion to the receipts. Better service, also, can often be rendered by one car frequently run than by a train making one or two trips a day.

The construction of these motor cars has usually consisted of a passenger car body with seats for about fifty passengers, one end being partitioned off to contain the boiler. A specially designed truck, carrying a vertical boiler and provided with horizontal steam cylinders, furnishes the motive power. Owing to the insufficient steaming capacity of the boiler, their development and use has not been as successful as might have been expected, nor has their introduction been as rapid. The limitations of vertical boilers within the height and space available is such that the cars have been very much handicapped with an insufficient steam supply. Even when fired in the best manner, it has been difficult to generate steam enough to supply the engines when working at maximum power. The heating surface, roughly speaking, is only about one-half that usually provided in modern locomotives. The fuel used in these cars has been coal, both hard and soft, and coke.

Two composite steam motor cars have been built at the Schenectady Works of the American Locomotive Company, one for the Erie Railroad on October 30th, 1897, and one for the New England Railway on October 9th, 1897 (See American Engineer, November, 1897, page 368). A number of other cars have been built by the different builders in this country, but as they usually have vertical boilers of less heating surface than those mentioned, it is not considered necessary to illustrate them. The same remarks and limitations, therefore, are equally applicable to them.

The largest number of composite motor cars have been operated by steam, but at the present time cars are being or have been built as follows:



SUGGESTED ARRANGEMENT OF STEAM MOTOR CAR.
ROCK ISLAND COMPANY.

First—Steam.

Second—Gasoline or oil engines in connection with direct coupled electrical generators and electric motors on the wheels. The arrangement of the motors, controllers, etc., is similar to the usual electrical street car method.

Third—Gasoline or oil engines with mechanical drive, operated by gearing and friction clutches.

While the use of gasoline provides some attractive features, being self-contained and not requiring any particular attention from the engineer except lubrication, the construction of these engines requires running at high speeds with a variation of not more than 40 per cent. or 50 per cent. Thus, in order to control the power and connect it to the wheels so that starting can be effected with smoothness and power, requires a large outlay for electrical or mechanical appliances. If controlled electrically, it requires a generator, two motors on the

COMPARISON.

STEAM MOTOR CARS.

Engine number	4611	.....	Proposed
Road	N. E. R. R.	Erie	.....
Gauge	4 ft. 8½ ins.	4 ft. 8½ ins.	4 ft. 8½ ins.
Weight on drivers	70,000	75,000	74,000
Weight on truck	45,000	39,000	F 15,000
Weight on trailer	.....	.....	B 40,000
Weight, total	115,000	114,000	129,000
Wheel base, driving	8 ft.	8 ft.	8 ft.
Wheel base, total engine	56 ft. 10 ins.	.....	62 ft.
Wheel base, total engine and tender	.....	.....	.....
Cylinders, diameter and stroke	12 ins. x 16 ins.	10½ ins. x 16 ins.	12 ins. x 16 ins.
Cylinders, spread	78 ins.	78 ins.	78 ins.
Driving wheels, diameter	42 ins.	42 ins.	42 ins.
Driving wheel centers, diameter	36 ins.	36 ins.	36 ins.
Driving wheel centers, material	Cast iron.	Steeled iron	Cast steel
Driving journals	7½ ins. x 9 ins.	7½ ins. x 9 ins.	7½ ins. x 9 ins.
Trailing wheels, diameter	.....	.....	.....
Trailing journals	.....	.....	.....
Engine truck wheels	.....	.....	28 ins.
Engine truck journals	.....	.....	5 ins. x 10 ins.
Frames, width	3½ ins.	3½ ins.	3—½ ins.
Boiler, type	Upright	Upright	Horizontal with return tubes
Boiler, diameter O. D. first ring	52 ins.	53⅛ ins.	60=½ ins.
Boiler, pressure	200 lbs.	200 lbs.	180 lbs.
Firebox, length and width	45⅜ ins. diam.	45 ins. diam.	48 3-16 ins. x 48⅜ ins.
Tubes, number of and diameter	318—1¼ in.	318 ¼-in.	397=1½ ins.
Tubes, thickness	No. 13	No. 13	No. 13
Tubes, length	4 ft. 8½ ins.	4 ft. 8½ ins.	7 ft. 6 ins.
Heating surface, tubes	489.6 sq. ft.	489.6 sq. ft.	875 sq. ft.
Heating surface, return tubes	.....	.....	350 sq. ft.
Heating surface, firebox	49.6 sq. ft.	49.6 sq. ft.	75 sq. ft.
Heating surface, total	529.2 sq. ft.	539.2 sq. ft.	950 sq. ft.
Grate surface	11.23 sq. ft	11.23 sq ft.	16.7 sq. ft
Tractive power	9,300	7,150	8,390
Factor of adhesion	7.52	10.49	8.82
Tank, type	2 cylindrical	2 cylindrical	2 cylindrical
Tank, water capacity	1,400 gal.	1,400 gal.	1,400 gal.
Tank, fuel capacity	1 ton coke	1 ton	1 ton

wheels and the usual arrangement of wiring, switches and controlling apparatus. It also involves the use of compressed air to start the engines. It is extremely questionable whether a gasoline-electric device of this kind would pay, unless gasoline could be obtained at an extremely low price or that coal could not be obtained except at a very high figure. The same argument is true of gasoline or oil engines with mechanical drive.

In reviewing this whole subject we are strongly of the opinion that a steam-driven composite car, with a large, properly constructed boiler (preferably horizontal), having sufficient steaming capacity and using fuel for oil, is the best solution of the problem. If the valves controlling the admission of oil and air were arranged very conveniently for the engineer, it would take but a small part of his time to control and maintain the steam pressure.

A preliminary design of such a car is shown. This car has a seating capacity of fifty passengers and a small baggage room. The steam connections between the boiler and engine are made with flexible ball joints. Such ball joints can be made in a satisfactory manner, and be guaranteed to give practically no trouble.

As fuel oil is abundant in different points in Kansas, Texas, etc., reached by the Rock Island System, it would seem to be peculiarly fitted for service on that road. The application of superheating pipes to the boiler should also be considered, as a large saving can be effected by their use, in water and fuel.

Illustrations and descriptions of a number of composite motor cars built at home and abroad are included in the report as follows:

Railroad.	Country	Motive Power.	Fuel	Total Weight
New England R. R.	U. S. A.	Steam	Coke	115,000
Erie R R.	U. S. A.	Steam	Coke	114,000
Proposed	U. S. A.	Steam	Oil	129,000
Great Western Ry.	England	Steam	Coal	.....
Taff Vale Ry.	England	Steam	Coal	.....
S. W. & L. B. & S. C.	England	Steam	Coal	.....
North Eastern	England	Mot. & Elec	Petrol.	73,400
Paris-Orleans Ry.	France	Steam	Coal	.....
C. B. & Q. Ry.	U. S. A.	Gaso.-elec.	Gasoline	.....
Midland	England	Steam	Coal	58,760

Motor Coaches Used by the Taff Vale Railway Between Cardiff and Penarth.—"These find much favor with the Taff Vale Company, who are about to construct six more motor coaches, propelled by steam, practically uniform with the one now running between Cardiff and Penarth. The dimensions of this motor coach are: Length over all, 58 ft. 9 ins.; width, 8 ft. 6 ins.; length of first-class compartment (seating capacity, 12), 8 ft. 11 ins.; length of third-class compartment (seating capacity, 40), 26 ft. 1½ ins. The first-class compartment seats are placed longitudinally and face each other; the third-class the seats are transverse, seating two passengers on each side. A central gangway runs throughout. There is no second-class, the seating capacity of the third-class being apparently designed to meet both classes. Though the running of this steam coach between Cardiff and Penarth has attracted public interest and support, it cannot yet be hailed as the fore-runner of the establishment of this means of transit in other directions, until the economy of working for it has been proved by experience. This consideration has undoubtedly been the moving power which has dictated the policy of the Taff Vale Company in introducing these steam motor coaches, apart from any hoped-for permanent stimulation of traffic that might be the reward of their enterprise. The cost of running them is said to be one-third that of running a train and four carriages, drawn by an engine of the type in ordinary use which they are intended to displace on that railway. In supporting this estimate we specifically show below cost running (1) a motor coach per train mile and (2) an engine and four coaches per train mile, respectively, namely:

	Motor coach cost per train mile. d.	Engine and four carriages cost per train mile. d.
RUNNING.		
Engine coal	1.36	3.03
Water	.12	.36
Oil and other stores	.19	.46
Cleaning	.07	.33
Steam raising, etc.	.09	.10
Washing out	.03	.08
Carriage lighting	.12	.32
Carriage cleaning	.10	.55
Oil	.01	.05
REPAIRS, RENEWALS.		
Engines	.95	3.48
Carriages	.51	2.75
WAGES.		
Enginemen	1.37	1.96
Trafficmen	.56	1.45
	(10.96 cts.) 5.48	14.92 (29.84 cts.)

(Extract from the "Railway Age," March 11th, 1904.)

Motor Electric Cars, Northeastern Railway.—Electric cars for the Northeastern Railway of England, 52 ft. long, seating 52 passengers, are driven by a four-cylinder petrol engine built by Wolseley Tool & Motor Car Company of Adderly Park, Birmingham, England, with a rating of 80 brake h.p. at 420 r.p.m. This drives a compound wound separately excited dynamo rated at 55 k.w., which supplies current to two 55 h.p. tramway motors mounted on the front truck of the car. The motor has cylinders 8½ x 10 stroke. Consumption of gasoline 0.78 pints per h.p. at full load.

Gasoline Electric Car Built by the C., B. & Q. Railway.—This car is driven with a 225-h.p. 3-crank engine coupled direct to a Crocker-Wheeler multi-polar generator mounted on the same bed plate. This car is made with a steel channel frame about 32 ft. long over the bumpers. The driving truck is a Peckham 4-wheel street car truck with 32-in. wheels directly under the engine, but on the other end of the car is a pair of trailing wheels working in a pedestal so that the car is carried on three pairs of wheels. The 4-wheel truck is supplied with two 125-h.p. street car motors. The engine, controller, air tanks, etc., occupy all but 11 ft. of the car, the remaining space of 15 ft. being used for carrying mail. The intention is to carry passengers in a trailing passenger car. A tank containing 300 gallons of gasoline is located underneath the car. The engine is started by means of compressed air, two tanks of which are provided, standing vertically on either end of the car inside the cab. The motor is supplied with an electrical air compressor similar to that used on heavy street cars. The engine is designed to run continuously at 325 r.p.m. The controlling apparatus, valves, etc., are placed in one end of the car only, the intention being to turn the car around at each end of the run.

The report presents the cost of operating a 300-h.p. motor car and also a statement showing the saving in operation of a motor car over that of a locomotive with a two-car train. These are presented in Tables 1 and 2.

Table 1.—Cost of Operating 300 Horse Power Motor Car.

Type of car.	Cost of fuel. Per gal. or ton.	Cost of fuel. Per pint or lb.	Lbs. or pints per h.p. hr.	Cost per h.p. hr.	H.p. hrs. per day.	Cost of fuel—Per day—While running.	Cost of fuel—Per day—Additional for raising steam.	Per 1,000 h.p. hrs.
Gasolene	$0.12	*1.5	1.	1.5 cts.	1,500	$22.50	$22.50	$15.00
Steam car with simple engines; oil fuel	.024	†.32	†2.8	.89	1,500	13.35	14.70 (10%)	9.80
Steam car, compound engines, superheated steam, oil fuel	.024	†.32	†2.1	.67	1,500	10.05	11.00 (10%)	7.33
Steam car, simple engines, coal fuel	2.15	†.1075	†4.	.043	1,500	6.45	8.06 (25%)	5.33
Steam car, compound engines, superheated steam, coal fuel	2.15	†.1075	†3.	.032	1,500	4.83	6.04 (25%)	4.03

*Pints. †Pounds. Running 100 miles a day. Average horse power assumed to be 150. Weight of oil, 7½ lbs. = 1 gallon.

Table 2.—Saving in Operation of Motor Car and Two Car Train with Locomotive.

Approximate cost:		
Passenger cars		$5,000
Baggage, mail and express cars		5,000
Engine and tender		7,000
		$17,000
Motor car		12,000
Difference		$5,000
Weight of train:		
Passenger car	35	tons.
Baggage car	30	"
Engine and tender	65	"
	130	"
Weight of motor car	65	"
Difference	65	"

Cost per day for wages:	Train.	Motor car.
Engineer	$3.50	$3.50
Fireman	2.25	2.25
Conductor	3.50	3.50
Brakeman	2.00	
Baggageman	2.50	$9.25
	$13.75	
Add for R. H. care	3.00	
	16.75	
Add interest on $5,000 at 6%	1.00	
	$17.55	

Cost of operation of train per day	$17.55
Cost of operation of motor car per day	9.25
	$8.30
Saving in fuel per day	5.00
Total saving per day in operation of motor car	$13.30

Capitalized at 5% $\frac{13.30 \times 360}{0.05} = \$95{,}760.$

ROLLED STEEL CAR WHEELS.

"Rolled-Steel Car Wheels" was the title of a paper by Mr. S. M. Vauclain, recorded in the *Journal of the Franklin Institute* for February, 1905.

The author first paid tribute to the cast iron wheel, which had done satisfactory service, but is now taxed beyond its limits because of increased wheel loads, it being impossible to increase the weight of the wheel in proportion to the loads. Brittleness of the flange, inability to resist the heating effect of the brake shoes, shelly treads and internal stresses in the castings had created a field for a wheel which would be free from these objections. The high-priced, steel-tired wheels which have been used under passenger equipment are considered too expensive for freight equipment. An "aching void" was left between the two. A safe, durable and cheaper wheel was wanted.

For making such a wheel long ingots were necessary. The process of manufacture was simple; a long upper section of the ingot must be discarded, the lower sections cut and pressed into blanks under a 5,000-ton hydraulic press, the blanks then rolled into wheels by special machinery, which would properly "work" the tire portion. The process of the Standard Steel Works was described. Tables of analyses and physical tests showed remarkable uniformity of the product. Drop tests of these wheels showed that 13 blows of a 2,240-lb. weight, 8 of which were from a height of 30 ft., were required to break a 36-in. wheel. Another wheel received 17 blows, of which 9 blows were at 25 ft., to break the wheel when struck on the top, in running position. Thermal tests were also fully met by these wheels.

Mr. Vauclain presented the following commercial comparison of steel and cast iron wheels:

SOLID ROLLED WHEELS.

Cost of pair of rolled wheels	$54.00
Cost of four turnings	2.40
Cost of four removals and applications	2.40
	$58.80
Less scrap value	8.75
Net cost	$50.05

Mileage, 350,000.
Cost per 10,000 wheel miles, $1.43.

CHILLED-IRON WHEELS.

First cost of pair of chilled-iron wheels	$18.00
Cost of boring and mounting	80
Cost of removal and application	60
	$19.40
Less scrap value	5.80
Net cost	13.60

Mileage, 80,000.
Cost per 10,000 wheel miles, $1.70.

It is usual for the railroads to determine the average cost of wheels by dividing the total yearly cost by wheel mileage made during the year. The statistics vary from 1.65 to 1.78, the average closely checking the foregoing estimate.

The natural field for the rolled wheel, according to Mr. Vauclain, is: (1) The severe service of engine and tender trucks, in which steel-tired wheels are now exclusively used. (2) Passenger car equipment, in which the element of safety plays an important part. (3) Heavy freight car equipment, for which the chilled-iron wheel has proved inadequate.

AN ECONOMICAL POWER PLANT.

A coal consumption as low as 1.7 lbs. per kilowatt hour under favorable conditions, and an average coal consumption of 2.25 lbs. per kilowatt hour for a period of three months, during which the load factor was .55 and the heat value of the coal used was about 13,500 B. T. U., is, indeed, a remarkable showing, and indicates that the gas engine and the methods of producing gas for its use have become developed to such an extent as to make it a formidable competitor of the steam engine. These results were obtained at the 705 h.p. gas engine power plant, which furnishes power and light for the malleable iron and the new steel plants of the Gould Coupler Company and also for the Gould Storage Battery Company's plant at Depew, N. Y. This power plant has been in operation for several months, and while figures are not yet available as to the cost of operation, indications are that it will be less than for a steam power plant of the same size.

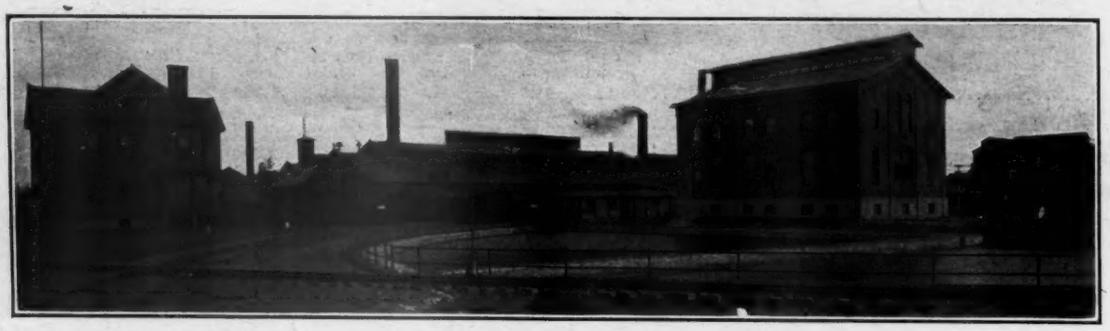


FIG. 1.—GAS ENGINE POWER HOUSE TO THE RIGHT, WITH RESERVOIR IN THE FOREGROUND.

Three 3-cylinder, 19 by 22 ins., Westinghouse 4-cycle, 235-h.p. vertical type gas engines operate direct connected 150-k.w., 250-volt direct current Westinghouse generators. The engines are guaranteed for 260 brake h.p., using gas with a heat value of 125 B. T. U. Ordinarily, two of the engines are sufficient to carry the load, but it is frequently necessary to use all three of them. A mixture of water and producer gas, as made by the Loomis-Pettibone process of the Power and Mining Machinery Company, is used. The engines are started by compressed air at 100 pounds pressure, which is furnished by a two-cylinder Rand, 6 by 6-in., compressor, driven by a 10-h.p. Westinghouse motor. One of these engines may be started and the full load thrown on it in less than a minute and a half. They can also be easily stopped at the starting point, which is just off the centre.

The ignition outfit consists of the standard Westinghouse spark coils, operated by a Diehl motor-generator and Gould storage batteries. Jacket water for the engine is pumped from the reservoir, shown in the foreground of Fig. 1, by Worthington turbine pumps. The gas engines, switchboard, ignition outfit, air compressor and air reservoirs are in a steel frame brick structure, inside dimensions 45 by 61 ft., with one end constructed with a view to future extension. This is equipped with a 10-ton hand traveling crane, the runways of which are 24 ft. above the floor. The pumps are in the basement of the building.

The arrangement of the apparatus in the gas producer plant is shown in Fig. 3. This consists of three gas generators, a boiler, wet scrubber, dry scrubber and exhauster. The gas holder, with a capacity of 15,000 cubic ft., is about half-way between the producer plant and engine room. The diagram in Fig. 4 illustrates the operation of a Loomis-Pettibone gas

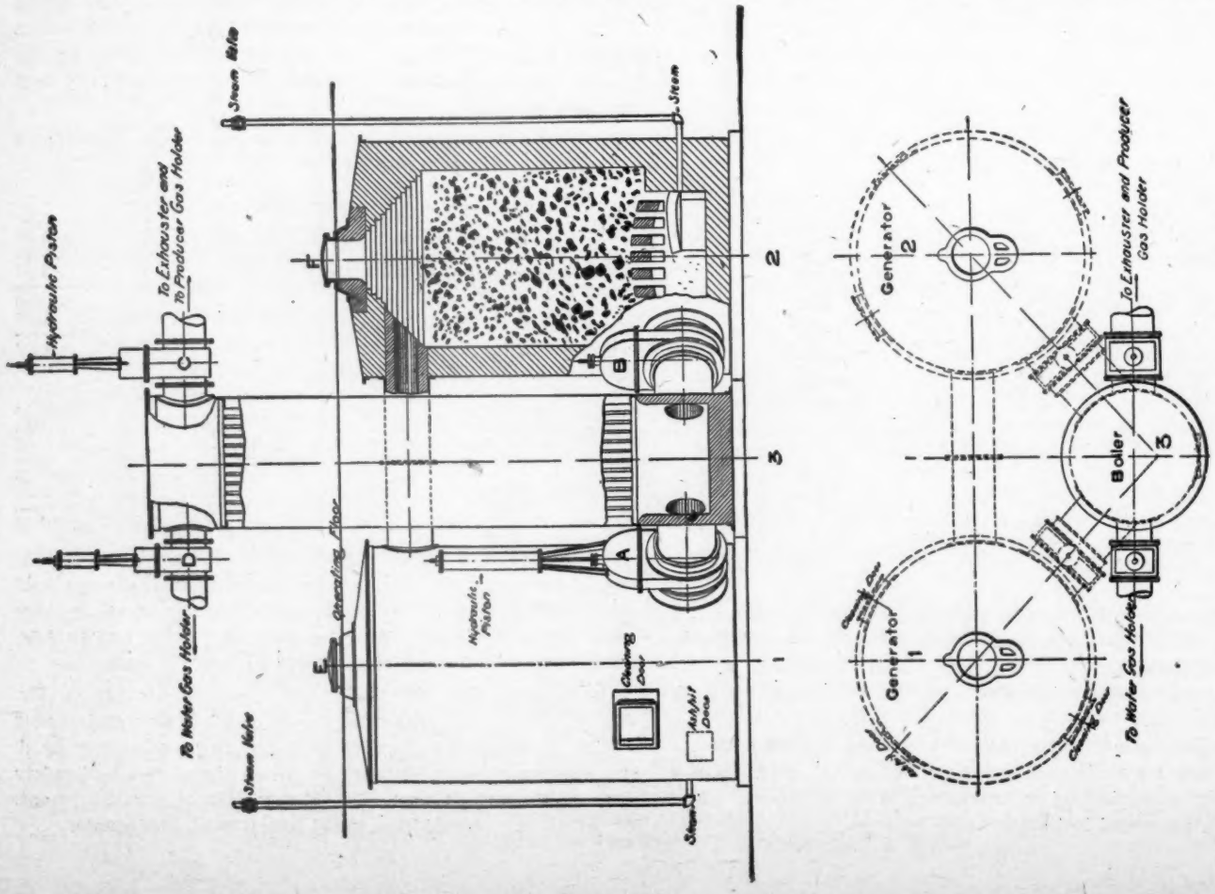


FIG. 4.—DIAGRAM SHOWING OPERATION OF LOOMIS-PETTIBONE GAS PRODUCER.

producer. The water gas and the producer gas, at the Gould plant, are conveyed to the same holder and mixed, instead of being kept separate, as shown in this diagram. In starting fires in the generators a layer of coke is put in and ignited at the top, the exhauster creating a downward draft. When this fuel is ignited bituminous coal is charged at intervals, as needed, through the feed door in the top of the generator. Air is admitted through the same door, and by means of the exhauster is drawn down through the fresh charge of coal and the hot fuel bed. The resultant producer gas is drawn down through the grates and ash pits of generators 1 and 2, valves A and B, up through the vertical boiler 3, and then through the wet and dry scrubber and exhauster to the gas holder. When the exhauster has brought the fuel up to incandescence the charging doors, E and F, are closed, and the valve B is lowered. Steam is then turned on into the ash pit of generator 2, and in passing through the incandescent coal is decomposed, forming water gas. From generator 2 the gas passes through the connecting pipe shown near the top of the generators, and down through generator 1, through the valve A, up through the boiler and thence, after being washed and cleaned in the scrubbers, to the holder. The process of making producer and water gas is alternated. In the next run of water gas the steam would be introduced into the ash pit of generator 1 and the gas would pass down through generator 2. At Depew the proper mixture for the engines is obtained by making producer gas for 15 minutes and water gas for one minute. As all the gas is made to pass through the fire, the tarry matter is converted into fixed gases. The percentage of condensable water vapor is very small.

FIG. 2.—INTERIOR OF ENGINE ROOM, SHOWING WESTINGHOUSE GAS ENGINES AND DIRECT CONNECTED ELECTRIC GENERATORS.

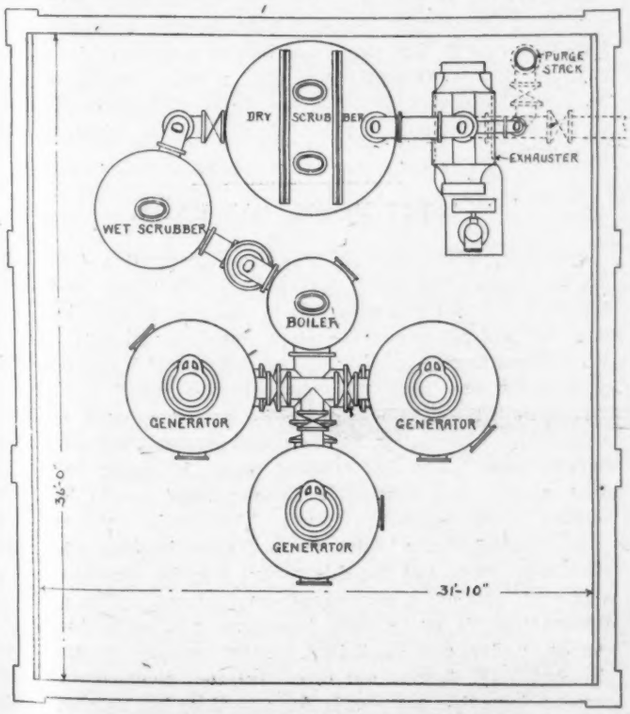


FIG. 3.—ARRANGEMENT OF THE GAS PRODUCER APPARATUS.

The reservoir, which has a capacity of 1,000,000 gals., is divided into two separate parts, one for the gas engine jackets and the other for the wet scrubber in the producer plant. It is 10 ft. deep, and is supplied by rain water from the roof of the steel plant. The fresh water flows into that part which is used for jacket water, and which must be kept as pure as possible. This overflows into the part used for the wet scrubber, and which is maintained at a slightly lower level, and must not be mixed with that used for the jackets, as it soon becomes dirty.

We are indebted for this information to Mr. F. P. Huntley, secretary of the Gould Coupler Company.

MANGANESE STEEL RAILS, BOSTON ELEVATED.—This road, because of serious wear of rails on its extraordinary curves, has put down a number of manganese steel rails which are cast because they cannot be rolled. The results thus far, according to the *Railroad Gazette*, are very satisfactory. These rails cost $5 per foot, while Bessemer rails cost but 38 cents. The difference in durability is considered to more than balance the increased cost.

SIMPLON TUNNEL.—This famous and difficult work, which began in August, 1898, has been connected, and within a few months will be in service for a single line of rails. When the traffic reaches $16,000 per mile annually the second tunnel will be completed by the Swiss Government. The Alpine tunnels are listed in *Engineering* as follows:

	Date of Opening.	Length, Miles.	Progress per day, Lineal Yards.	Cost Lineal Yard.
Mt. Cenis	1871	7½	2.5	$1,130
St. Gothard	1881	9½	6.01	715
Arlberg	1883	6½	9.07	540
Simplon	1905	12½	9	540

(Established 1832).

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Contributions.—*Articles relating to railway rolling stock construction and management and kindred topics, by those who are practically acquainted with these subjects, are specially desired. Also early notices of official changes, and additions of new equipment for the road or the shop, by purchase or construction.*

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We cordially invite our many friends attending the conventions at Manhattan Beach in June to make use of our offices. Telegrams and mail addressed in our care will receive careful attention.

INTERNAL COMBUSTION ENGINES.

There is no reason why the remarkably low average coal consumption per k.w. hour at the gas engine power plant, described on another page of this issue, could not be duplicated if similar plants were installed to furnish power for railroad repair shops. Its operation is, if anything, more simple than that of a steam plant. The gas engine and the methods of producing gas for its use are beyond the experimental stage and are thoroughly reliable. It is interesting to note in this connection that the preliminary report of the United States Geological Survey on the coal-testing plant at the Exposition shows that for comparative tests of 14 different bituminous coals one ton used in a gas producer plant developed as much power on a commercial scale as 2½ tons of the same coal used in an ordinary steam plant. The importance of this question merits the careful study of those contemplating the construction of new power plants.

ELECTRIC TRACTION FOR STEAM ROADS.

The trend of the discussion on this subject at the March meeting of the New York Railroad Club indicated that there was still much uncertainty as to how far the single phase alternating current system will displace the direct current system for this work, because of the pulsating torque of the A. C. motor and the relative lower emciency and higher first cost and also the fact that the apparent resistance of the trolley and track is from one-half to twice as great for the alternating current as for the direct current. Much depends upon the practical experience to be gained from the single-phase alternating-current systems now in use and about to be installed. Apparently, steam roads will adopt electric traction, not because of economy in operation, but because of other advantages to be gained by its use. While improvements will undoubtedly be made in the electric motors much progress will also be made in the next few years toward making the steam locomotive more economical. Most of the speakers favored the use of the third rail in preference to the overhead trolley. The speakers were very cautious in their prophecies concerning the substitution of electric traction on steam roads.

WEARING-OUT POLICY FOR SHOP MACHINERY.

It is one thing to abuse shop tools and quite another thing to use them up quickly in legitimate work. The writer recently heard a general foreman scold a machine hand severely for damaging a tap, which, in his anxiety to turn his work out quickly, was injured in the machine. This brought to light the fact that in that shop a rule is in force requiring a broken tool to be taken to the general foreman and a satisfactory explanation given before another tool can be issued to the offender. Such a rule as this may work harm rather than good, and it is a question whether it is advisable to lay such stress on the breakage of small tools when in legitimate service, for the reason that men may easily be led thereby to nurse the machines and the tool equipment at the expense of the output. If a good system is in force it is not likely that machine operators will wilfully break their tools and as a general proposition it would be advisable to break a good many, if thereby a sharp pace may be gained in the shop. Of course, wanton destruction should be guarded against.

No one nowadays thinks of nursing a locomotive at the expense of its output, but it is considered a great mistake to encourage men to take such care of the machine as to limit the work done. Within reasonable limits the policy in a railroad shop to-day should be to wear out the tools and machinery in an effort to get the proper value out of them day by day. As to machine tools it would seem to be an excellent policy to fix on a certain period of years as the maximum life of the tools and to push them to the utmost to accomplish their life work in that time. Instead of giving an honored place to antiquated machinery, in an otherwise modern railroad shop, these tools should at the proper time give place to new ones, providing improvements in that particular line of machinery justify the change. A general adoption of such a policy would lead to a business-like plan of providing for depreciation, as is suggested in the admirable paper by Mr. M. K. Barnum, which appears in this issue.

LIGHT MOTOR CAR UNITS.

A correspondent recently asked for information concerning the development of motor cars for relatively light service on branch lines, and was surprised to find that so little had been done in this country. His letter closed as follows:

"It seems to me very curious that a field which presents such possibilities has been left undeveloped so long."

In Europe the development has been much greater, although electric line competition has been less serious there than here. Careful attention to this problem cannot be longer delayed in this country, and substantial developments are to be forthcoming in the immediate future. These light units are only to be considered as a bridge across the gap between steam and electric traction, and for this reason may be considered as a makeshift and not a permanent development. The problem, nevertheless, is exceedingly important and attractive. We cannot, under our conditions, follow present foreign practice, but must develop our own. Internal combustion motors present favorable arguments for adoption, but opinion is divided as to whether, after all, steam is not the only satisfactory power for this purpose. If so, the line to be drawn between a light steam locomotive and the self-contained unit is a difficult one to draw. The report of the Power Committee of the Rock Island System on this subject is one of the most important recent documents relating to it, and this appears elsewhere in this issue.

Unless a steam boiler of high capacity for its weight is developed, it will be difficult to use steam because of boiler limitations. In this connection the flash boiler has interesting possibilities and it is now receiving attention from engineers who have been associated with the greatest developments of power for railroad transportation.

Gasoline engines are being tried with fair promise of success, but kerosine engines are considered seriously for the next step in development because of the superior safety of the heavier oil. This is an important factor.

The demand for light units has appeared in proportion sufficient to merit the attention of the ablest engineers, and this in itself is sufficient assurance that it will soon be met.

LOCOMOTIVE TESTING PLANT.

PENNSYLVANIA RAILROAD.

This plant was designed and built with a view of permanent installation at Altoona, after the close of the World's Fair at St. Louis. While accessories may be changed, the plant itself is to be erected again, probably without important changes. Its original construction was rapid, and the design provided for gauges permitting the work to progress simultaneously at Altoona, where many of the details were made, and at Philadelphia, where the dynamometer and main bearings were built in different establishments. The plant was not assembled before its erection at St. Louis. Fig. 1 presents a side elevation as arranged at St. Louis, and Fig. 2 is an end view.

Upon a very large concrete foundation (Fig. 1), gradually increasing in depth toward the rear and deepest under the dynamometer, two cast iron bed plates were placed. These were slotted to receive the bolts for the pedestals of the carrying wheels, rendering them adjustable for locomotives of varying wheel bases, varying number of wheels and different wheel spacing. A set of 5 pairs of supporting wheels were 50 in. in diameter and another of three pairs of 72-in. wheels were provided, the smaller ones being for freight and the larger for passenger locomotives. Each set of carrying wheels had a corresponding set of pedestals fitted with very large, carefully designed bearings, having provision for water circulation to insure cool running. An exceedingly important part of the plant, which cannot be properly illustrated, was the arrangement of moveable track at the front end of the engine, which was adjusted longitudinally to suit any engine to be put upon the plant. This telescopic track was successful in every way and contributed largely to the satisfactory handling of the plant. Fig. 4 shows in section one of the long I beams extending the full length of the plant. After the supporting wheels are spaced and trammed, these beams are bolted to the inside faces of the supporting wheels and the flanges of the drivers of the locomotive run in the groove in the rail which is bolted to the I beams. The drivers rise slightly on their treads as they pass over the carrying wheels, and finally stop when each driver is resting upon its wheel. The I beams are then taken away from the carrying wheels, the truck is supported on the structure shown in Fig. 5, and the locomotive is ready for attachment to the dynamometer.

Fig. 4 also shows the tire of the carrying wheel in section, with the inclined groove, cut out, to throw oil from the outer edge of the tire, away from the locomotive tire, in case oil gets upon the supporting wheels. Fig. 4 also shows the tire retaining ring which, with the shoulder on the wheel center, holds both ways. One of the supporting wheels, the bearing and the brake are shown in Fig. 6, and the construction of the brake and the end of the supporting axle are shown in Fig. 3. The sectional views indicate the method of removing the brake from the taper fit at the end of the axle. A nut forces the brake on the shaft and another forces it off. It also shows the centrifugal oil grooves at the brakes. The Alden brakes consist of outer casings held from revolving at R, R. Discs D attached to the hub, revolve inside the casing when the supporting wheels are turned. Against these discs copper plates, C C, attached to the casing bear with hydraulic pressure and cause the desired resistance by friction upon both sides of the discs. The discs have radial grooves and lubrication is provided to avoid heating and seizing. The spaces marked W contain circulating water under pressure, causing the plates to bear heavily against the discs. By varying this water pressure the speed of the locomotive is under practically perfect control. It is varied by throttling the outflowing water, this circulation serving to carry away the heat resulting from the friction. The discs are oiled from a large supply at the center of the casing, on each side, and oil is carried to the outside of the casing by centrifugal force, being discharged upon each side at the top. It therefore circulates when the plant is running.

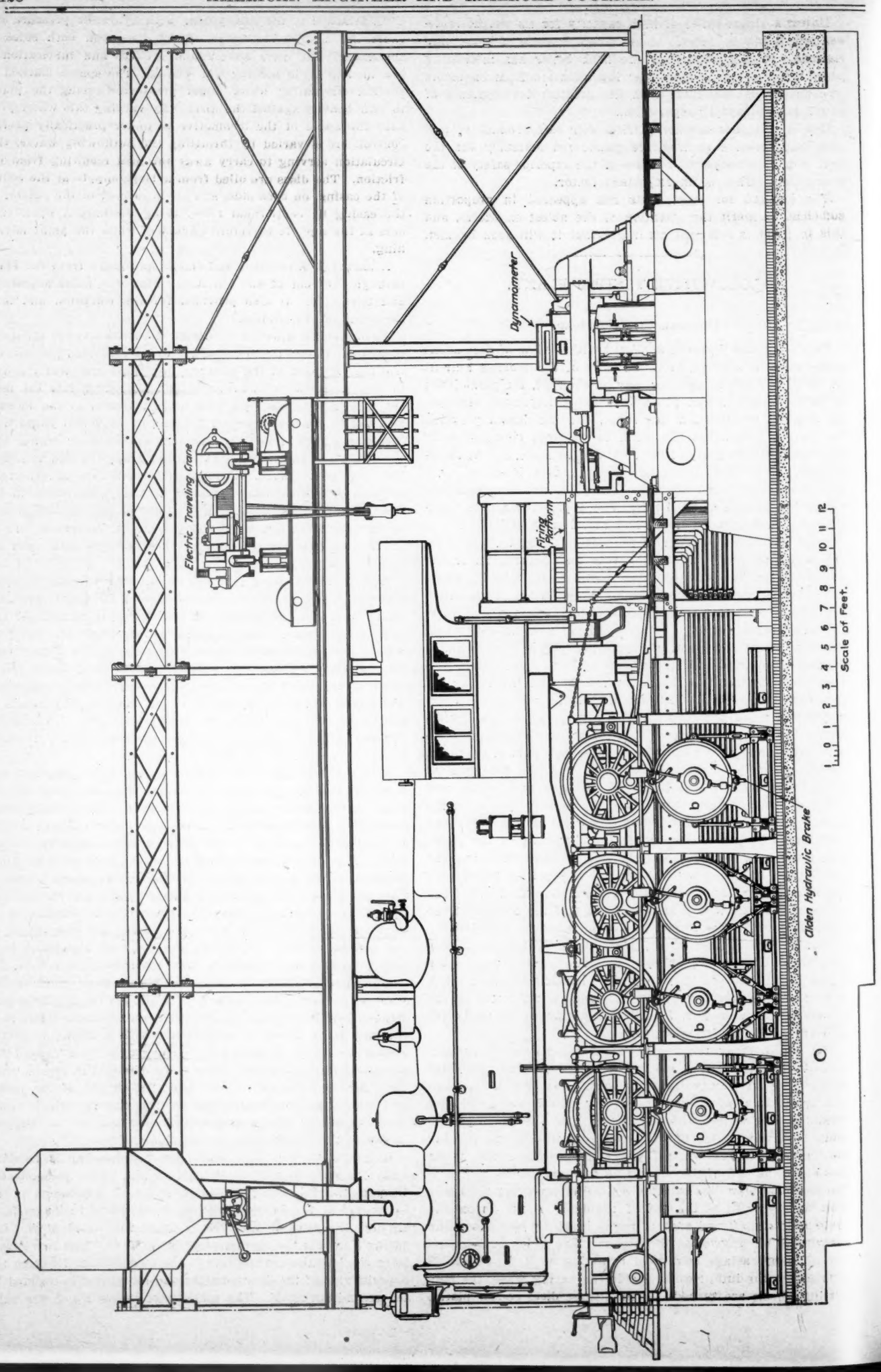
A smoke jack removed the smoke and gases from the stack through the roof of the building. This was made adjustable and telescopic. It also provided for the retention and measurement of the cinders.

An adjustable drawbar connected the locomotive to the dynamometer. It was found necessary to provide dash pots to control the vibration of the drawbar, and these are clearly shown in Fig. 7. In order to avoid introducing errors into the measurements, these dash pot rods were attached to the locomotive and to the dynamometer housing by universal joints with carefully designed and constructed adjustments, which also permitted the attachments to be easily applied and removed. The dash pots contain oil supplied from founts and their resistance to motion was adjustable by means of valves in the casings. The dash pots are in the form of double discs ground to fit their cylinders with about 0.001 in. clearance. These are arranged so that only a static head of oil comes upon the stuffing boxes.

A very large housing provides for the 80,000-lb. Emery dynamometer, built by Messrs. Wm. Sellers & Company, Philadelphia. This is a development of the Purdue dynamometer and that of the Pennsylvania Railroad dynamometer car, employing Emery flexure fulcrums, which were used in the Emery testing machines. These are well adapted to carry large levers under heavy loads and yet introduce only negligible friction. The dynamometer is adjustable 12 ins. vertically by means of screws turned by a hand wheel, shown in Fig. 9. This adjustment permits the height of the drawbar to vary from 30 to 42 ins. above the rail level.

In the engravings, Fig. 9 shows a side view, plan and end view of the dynamometer structure, the recording attachments being shown in Figs. 8, 10 and 14. The dynamometer housing is very substantial, consisting of the castings A and B, with projections extending down into the concrete foundation. The dynamometer itself is placed between the abutments C, which are connected together by the heavy plates B. This structure must necessarily be very rigid, and the anchorage to the foundation secure. The drawbar connection is shown at the right of the side view in Fig. 9. The weight of the drawbar is taken upon two flexible steel plates and it is held in alignment by flexible rods, which provide for its motion without friction. A ball and socket joint permits the drawbar to accommodate itself to slight motion of the engine without bending the connection. The dynamometer itself is so compact as to render a description from working drawings impossible. Fig. 13 shows the principal parts arranged for purposes of explanation. This view shows the levers, with their Emery fulcrums. To support the weight of the levers and prevent both horizontal and vertical stresses, which would cause errors in the measurements, the method of support shown in the sketch, Fig. 11, was adopted.

Referring to Fig. 13, a pull upon the drawbar is received upon the yoke E, moving it to the right. This is connected through the fulcrum plate to lever No. 1, fulcrumed at its lower end at f1. Lever 1 transmits this force to lever No. 2 through the piece Q, lever No. 2 being fulcrumed at f2. The spring V resists the movement of lever No. 2. The force from lever No. 1 is also transmitted to the second lever No. 2 on the opposite side of the dynamometer and its motion is resisted by the second spring V. The motions of levers No. 2 are com-


Dynamometer
Electric Traveling Crane
Firing Platform
Alden Hydraulic Brake
Scale of Feet.
0 1 2 3 4 5 6 7 8 9 10 11 12

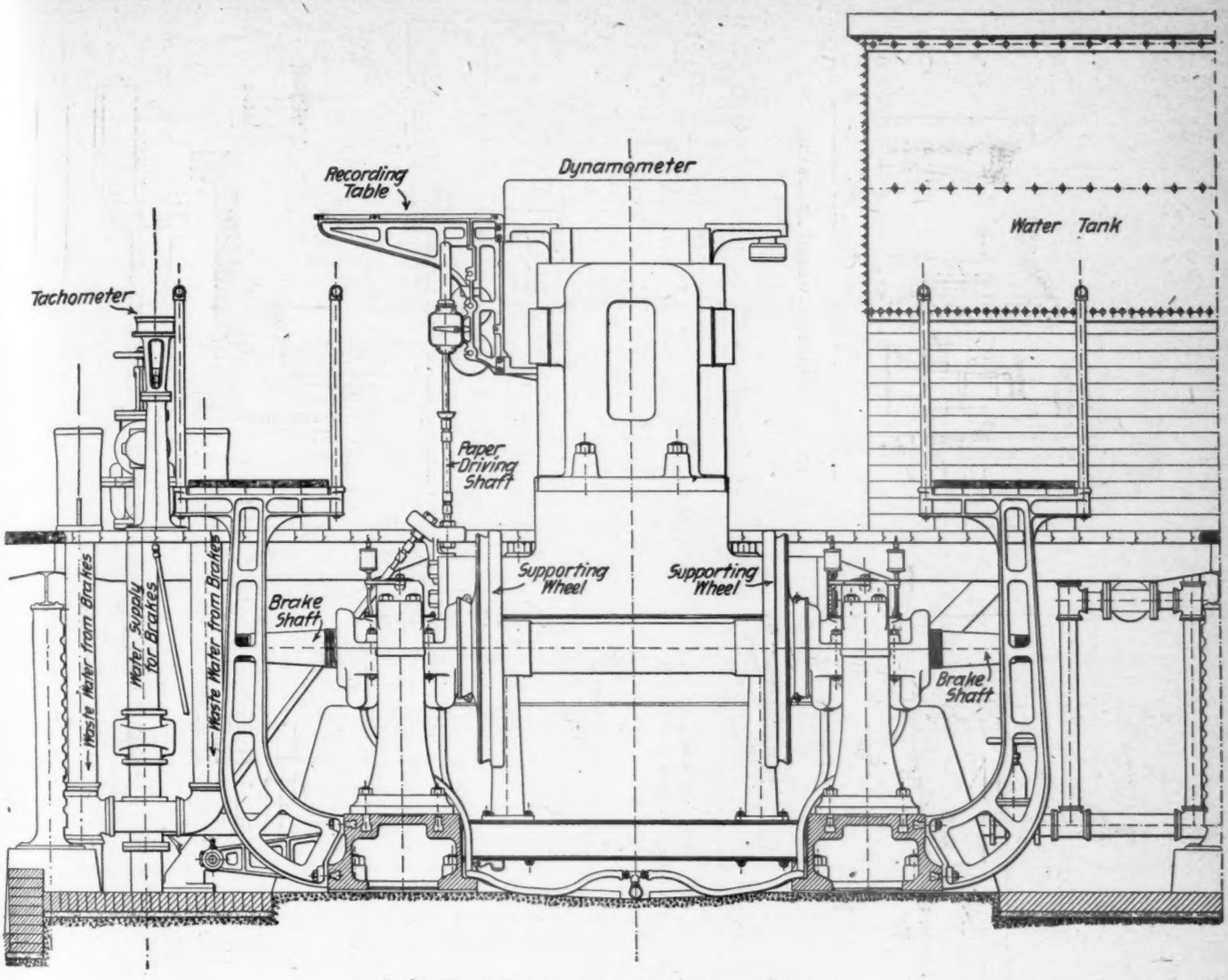


FIG. 2.—END ELEVATION OF LOCOMOTIVE TESTING PLANT.

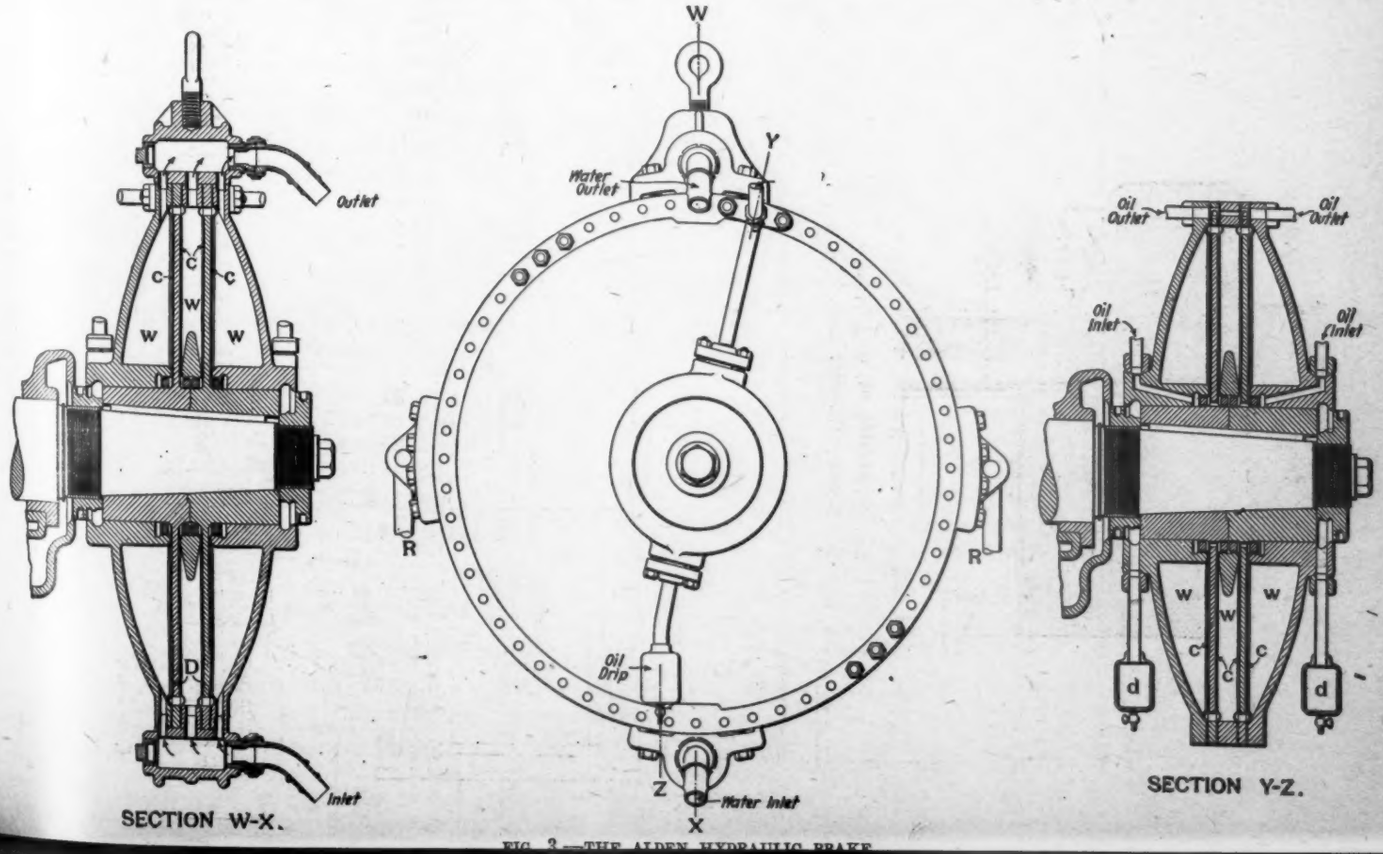


FIG. 3.—THE ALDEN HYDRAULIC BRAKE.

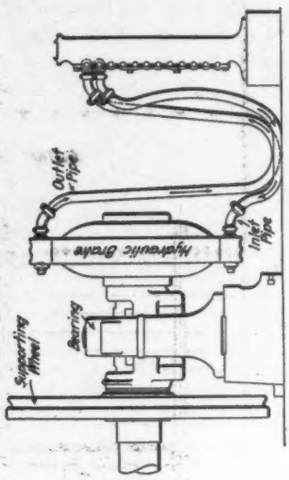


FIG. 6.—SUPPORTING WHEEL AND BRAKE.

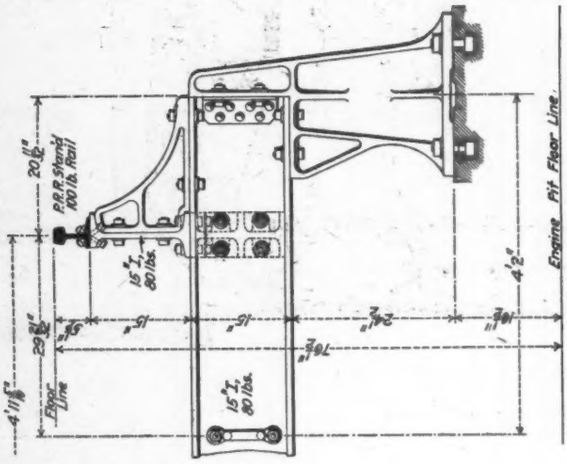


FIG. 5.—SUPPORT FOR TRUCK WHEELS.

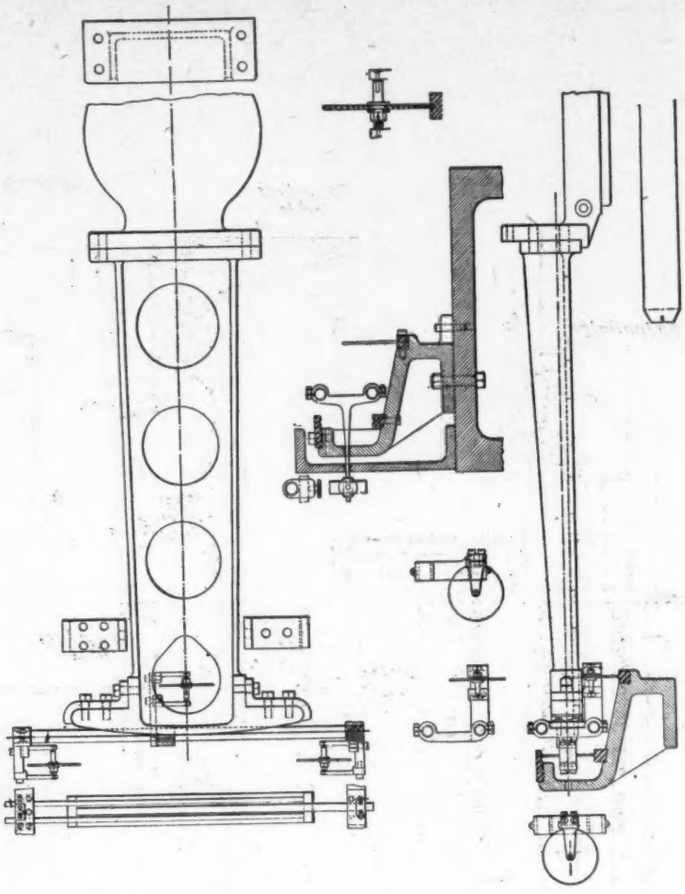


FIG. 8.—RECORDING PEN ARM.

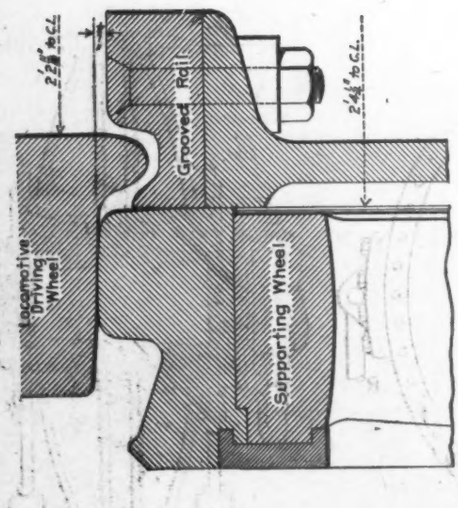


FIG. 4.—METHOD OF MOUNTING LOCOMOTIVE DRIVERS.

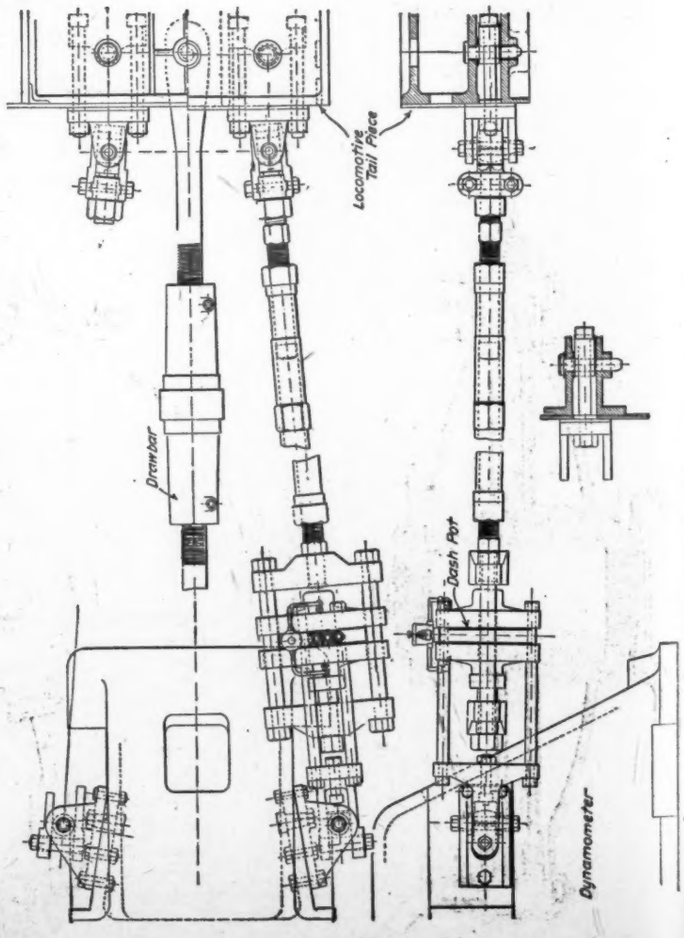


FIG. 7.—DRAWBAR AND DASH POTS.

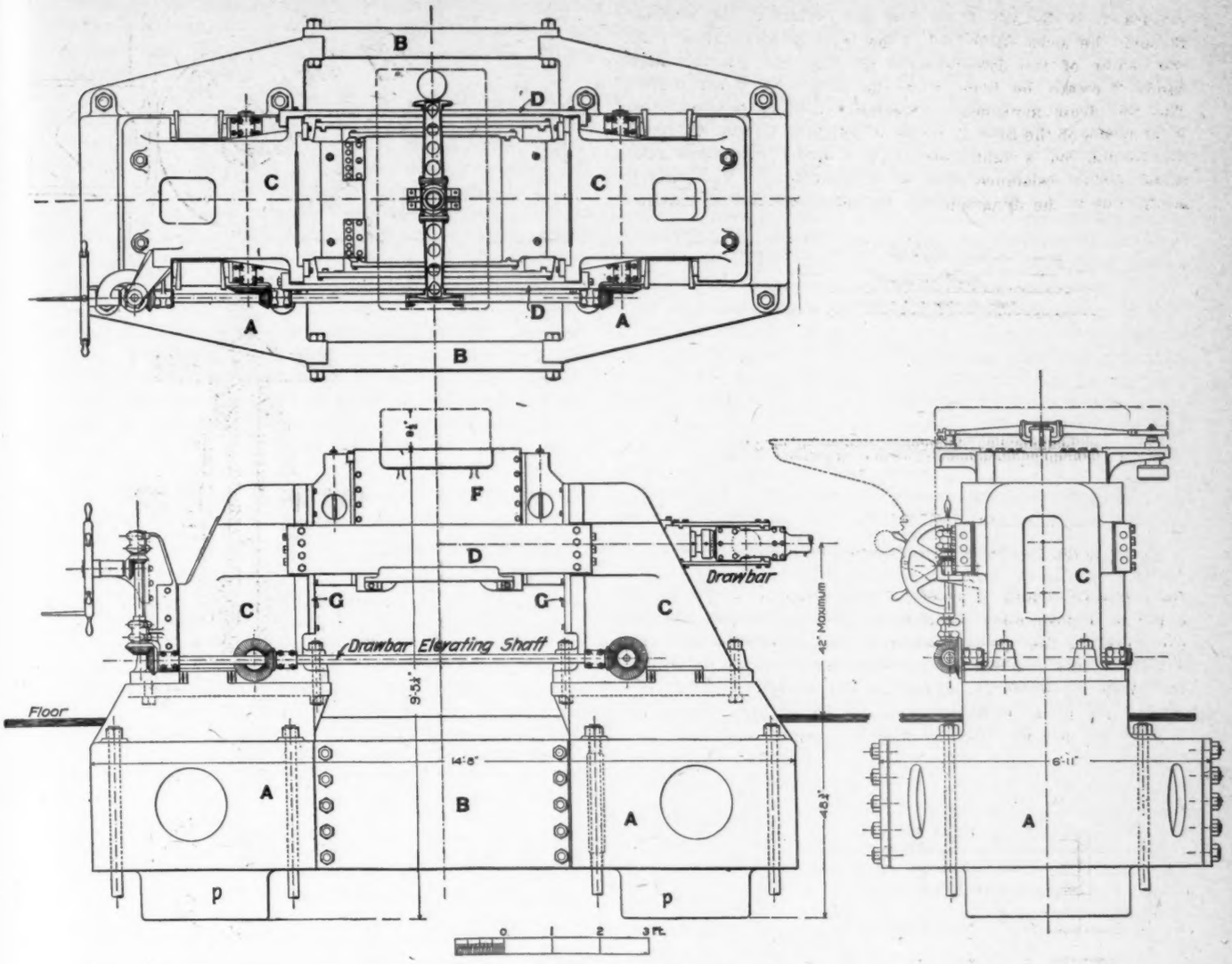


FIG. 9.—GENERAL ARRANGEMENT OF DYNAMOMETER.

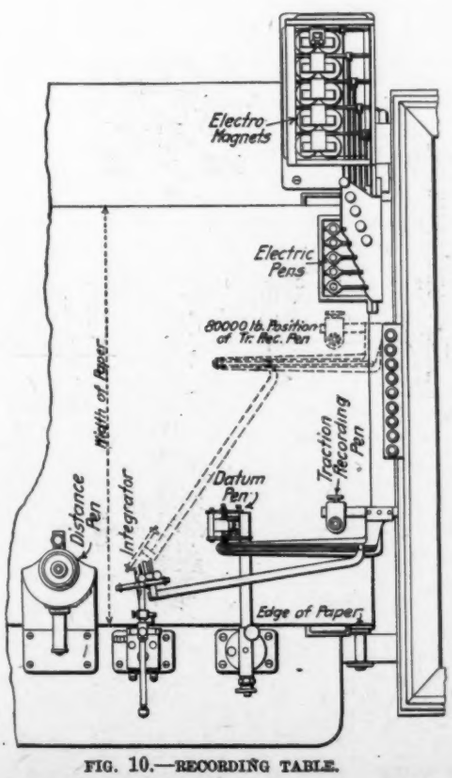


FIG. 10.—RECORDING TABLE.

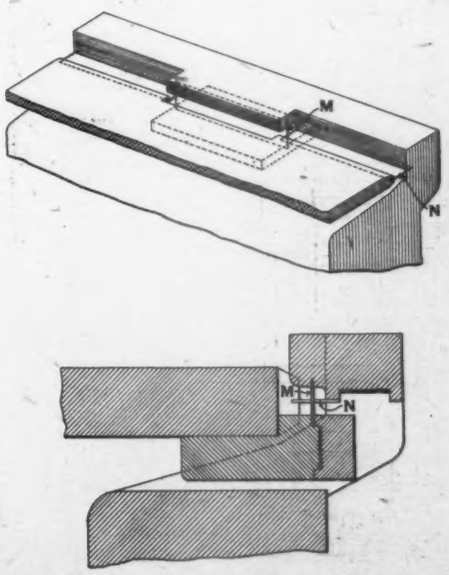


FIG. 11.—EMERY FULCRUM PLATES.

municated to the belt drum J at the bottom of the machine through the arms O, shown in the inverted plan view, from the center of the dynamometer in Fig. 13. Flexible steel bands N rotate the drum when the levers No. 2 are moved. The belt drum movement is communicated to the pen lever P by means of the tube H inside of which is the torsion rod I. The torsion rod is rigidly secured at L and it introduces additional spring resistance into the dynamometer. The plate R at the top of the dynamometer furnishes connection between

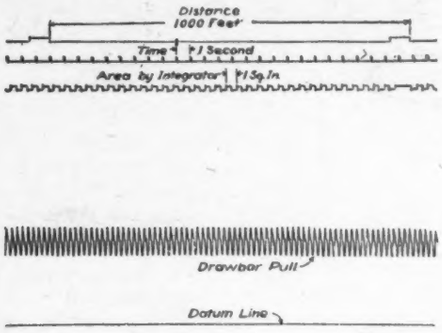
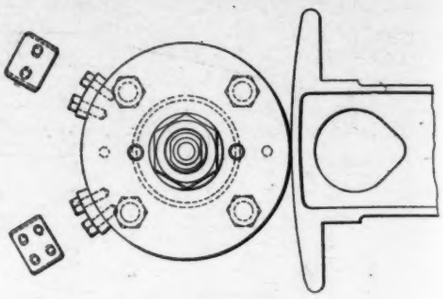
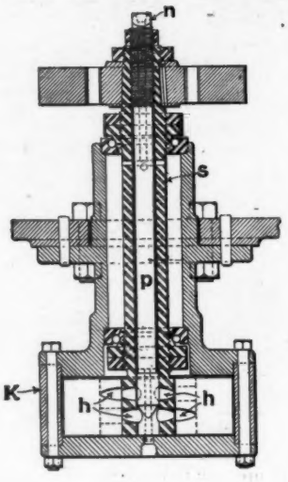


FIG. 12.—TYPICAL DYNAMOMETER RECORD.

the levers No. 2, and by means of this system of levers either a pull or a push upon the drawbar rotates the pen lever P after meeting the spring resistance already mentioned. The springs V are supplied in various capacities up to 80,000 lbs. With the 80,000-lb. springs the dynamometer records 10,000 lbs. per in., as measured from the datum line. The scale is 5,000 lbs. per in. with the 40,000-lb. springs and 2,000 lbs.





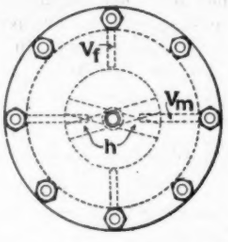


FIG. 14.—PEN ARM DASH POT.

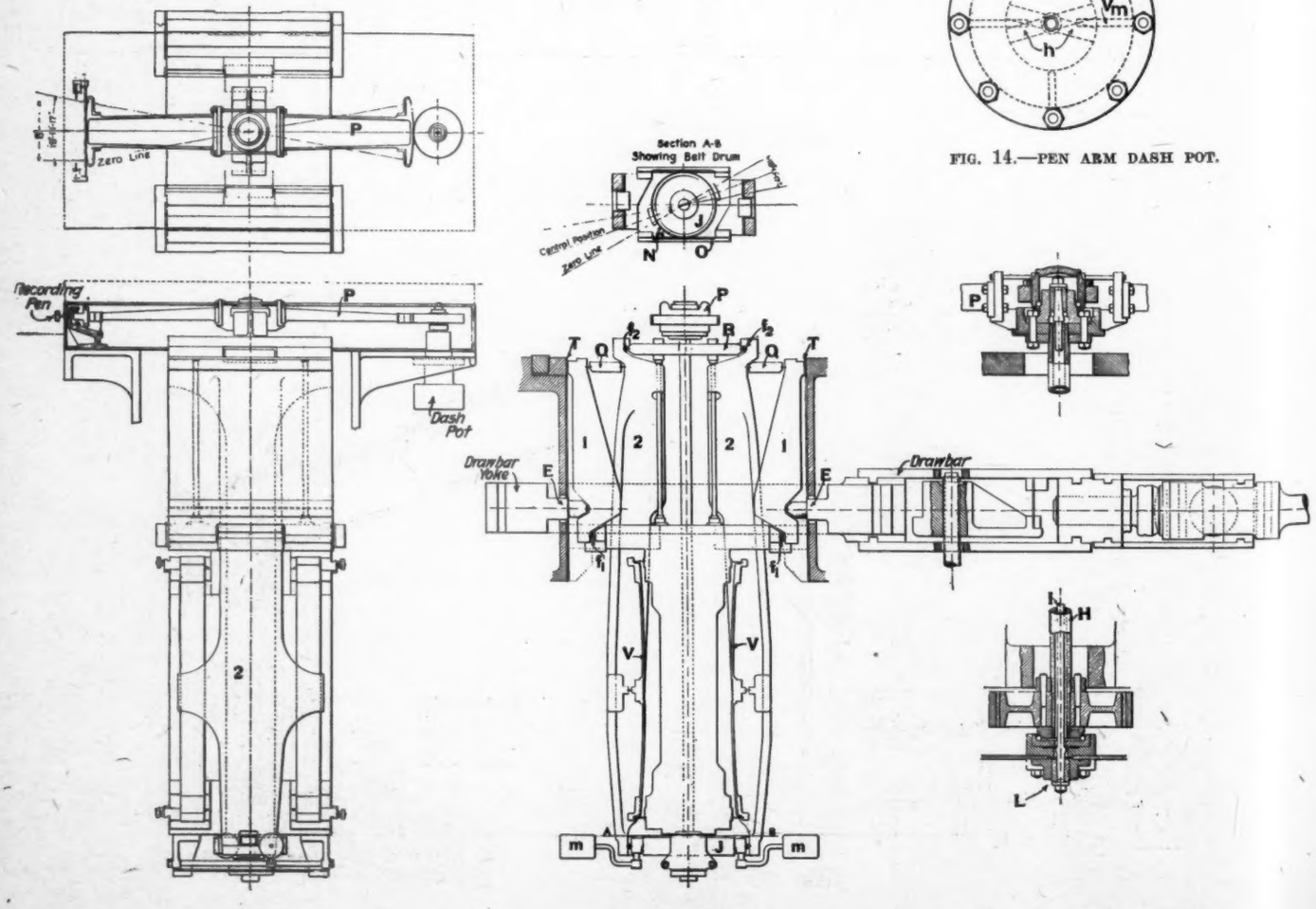


FIG. 13.—DYNAMOMETER WEIGHING LEVERS.

per in. with the 16,000-lb. springs. In these measurements the drawbar movement at the full capacity of the dynamometer is not more than 0.04 in. The recording mechanism increases this movement 200 times.

The recording mechanism, Fig. 10, is brought to a table bracketed to the dynamometer. The pen lever, Fig. 8, carries at its left hand end a segment, which, by means of steel tapes, gives to the pen carriage a rectilinear motion, the other end of the pen arm being provided with a rotary dash pot, shown in Fig. 14. In the plan view the vanes Vm are shown. These are turned in the cylinder K, being rotated by the shaft S. Fixed vanes, Vf, project from the walls of the cylinder between the center of the dash pot, the dash pot being filled with oil. Small holes, h, permit the oil to pass freely from one side to the other of the moving vanes when they are open. By turning the nut n at the top of the dash pot the holes h are partially closed and the resistance is made adjustable. Fig. 14 shows the ball bearings in the dash pot—in fact, all rotary motions in the dynamometer are made on ball bearings.

Fig. 10 shows the recording table with the datum pen, 5 electric pens, distance pen and a traction recording pen. The table mechanism was most carefully designed to insure smooth and regular motion of the paper, to reverse the direction of the driving mechanism in order to keep the paper moving in the same direction on the reversal of the locomotive, and this entire mechanism is carefully arranged so that the paper may be replaced quickly. The drawbar record is automatically integrated by the integrator shown in Fig. 10. The support for the moving paper under the integrator roller is a roller journaled under the table and the integrator roller does not wear or cut the paper. A distance marking roller records every 1,000 ft. of motion by automatic electric contacts. The recording apparatus merits a description by itself. The paper runs at the rate of 52.8 ins. per mile, giving a scale of 100 ft. to 1 in. Fig. 12 shows a sample record. A splined shaft drives the drawing rollers of the mechanism. The paper passes from the bottom roller to the top of the table, along to the outer guide roller, then to a finely corrugated brass roller; then to a calendar roll covered with rubber, and finally to the upper drum, the speed of which is sufficiently fast for all conditions. This is arranged to slip upon its shaft to take care of varying diameters of the receiving roll. The corrugated roll referred to always maintains the same relation to the speed of the support wheels.

This plant as installed at St. Louis was referred to in this journal on pages 29, 301, 365 and 400 of the volume of 1904.

A PLAN FOR MAINTAINING RAILROAD REPAIR SHOP MACHINERY.*

By M. K. Barnum.

If I were at the head of the mechanical department of a railroad and should be required to choose between an old shop fully equipped with strictly up-to-date machine tools and a new shop provided with traveling cranes and other similar modern appliances, but in which a lot of old tools were to be retained, I would unhesitatingly prefer the former as being the most efficient means of maintaining the rolling stock and the best investment of the railroad company's money.

There is one railroad whose shops a few years ago were full of worn-out and obsolete machinery, and in spite of large purchases of locomotives the conditions grew so bad that it was impossible to maintain the power in good working order; engine failures increased to three times the average on neighboring roads, and the train service became utterly demoralized. Finally an emergency existed, and as a last resort it was decided to buy some new machinery. The obsolete tools were replaced with up-to-date machines and some additions made to the equipment of all the shops, which resulted in an increase of over 50 per cent. in the output of locomotives, and that with less than a 10 per cent. increase in shop payrolls. Engine failures were reduced by two-thirds, and a steady improvement was made each month in the condition of power. Another railroad company has an old locomotive erecting and machine shop containing only 21 pits, but this shop turns out with general repairs from 45 to 50 engines a month. Whenever any machine can be replaced with one which will earn 10 per cent. or more on the investment the old one is discarded, and this practice has necessitated throwing out upwards of $25,000 worth of old machinery within the last few years, but it has also resulted in a shop well supplied with up-to-date tools and with none that are really obsolete. This shop overhauls each month from 2 to 2½ locomotives on each pit, while most other railroad shops average about one a month to each pit. It is hardly necessary to add that the management is very progressive and efficient. The same policy is followed largely in all the shops of the road under consideration, and the average cost of repairs per locomotive last year was less than $1,600, while it ranged between $2,000 and $3,000 for most other roads.

Some idea of the tenacity with which railroads cling to old machinery may be obtained from the lists below, showing the age of all the shop tools owned by two roads, neither of which can be considered an exception to the general rule:

	A. B. C. R. R.		X. Y. Z. R. R.	
Age of Tools.	No. of tools.	Per cent. of whole.	No. of tools.	Per cent. of whole.
Less than ten years old.....	517	33	193	24
Ten to twenty years old.....	472	31	269	33
Twenty to thirty years old....	193	12	113	14
Thirty to forty years old.....	137	9	102	12½
Forty to fifty years old.....	15	1	12	1½
Not known, but very old.....	211	14	125	15
Total	1,545	100	814	100

Please note particularly that 36 per cent. of all the A B C road's tools and 43 per cent. of the X Y Z road's tools are over 20 years old, while about one-sixth of the machines of each road are over 40 years old.

After a new shop is built and equipped, most railroad companies seem to think it can be operated and maintain its efficiency indefinitely without renewals or additions of machinery, but after 15 or 20 years they find the cost of work increasing and the shop output decreasing, and then they may wake up and place a big order for new machinery. One road recently bought nearly $200,000 worth of machine tools at one time for its old shops, but it would have been much better policy to buy some machinery every year, as each machine could be selected with more care and the merits of the different makes and patterns of machines could be more carefully investigated, and those chosen which were best adapted to the particular work to be done. By this plan it would also be possible to more promptly equip new machines with the small tools and special devices for holding and doing work, which are so necessary to obtain the maximum output.

Every railroad company should start a "Depreciation Fund" for maintaining the efficiency of its shop tools. Some companies now have such a fund for replacing cars and locomotives which are wrecked or worn-out, but I know of none that makes such a provision for its shop equipment.

The tools in each shop should be inventoried and valued according to their age and condition. The inventory should show for each tool the following information:

1. Location of the shop on the road. 2. Location of tool in shop—as tool room, boiler shop, etc. 3. Kind of tool and brief description. 4. Weight of tool, approximately. 5. Name of maker. 6. Date when made. 7. Present condition. 8. Original value. 9. Depreciated value—allowing 5 per cent depreciation per year until reduced to scrap value at ¾c. per lb., which would be the minimum value that should be placed on any machine.

Some machines wear out or become unprofitable to operate much sooner than others, but I believe an allowance of 5 per cent. a year is conservative and will average about right for railroad shops.

A table is submitted herewith giving the number and value of tools in six repair shops located on different roads. The names of the roads and location of shops are withheld for obvious reasons, but these are all actual figures for existing shops, which will afford a good idea as to the value of machinery in shops of different sizes; namely, those having a capacity for giving general repairs to 60, 120, 216, 300 and 600 locomotives per year, respectively. None of these shops is over 25 years old and some are quite recent, but all may be considered fairly well equipped with machinery in proportion to the amount of work to be done.

An annual appropriation of 5 per cent of the value of the machinery in each shop would practically renew it once in every twenty years and maintain it in a fair state of efficiency.

I believe the most successful manufacturers figure on renewing their machinery oftener than this—once in 10 or 15 years, for manufacturers of tools, etc., and cotton mills once in 7 to 10 years—but I do not think it necessary to renew railroad shop machinery quite so often.

*Paper read before the Western Railway Club.

Items—	Shop A. No. of tools.	Shop A. Value.	Shop B. No. of tools.	Shop B. Value.	Shop C. No. of tools.	Shop C. Value.
Machine shop	30	$16,655	50	$56,573	122	$134,975
Tin and pipe shop (includes bench tools)	12	105	11	400	48	383
Boiler and tank shop (includes furnaces, clamps, etc.)	6	750	6	5,724	36	25,680
Blacksmith shop (includes hammers, etc., but not forges)	1	1,200	5	3,746	15	14,350
Planing mill		None.	24	10,154	33	12,681
Total	49	$18,710	96	$76,597	254	$188,069
Five per cent. of total	..	935	..	3,830	..	9,403

Items—	Shop D. No. of tools.	Shop D. Value.	Shop E. No. of tools.	Shop E. Value.	Shop F. No. of tools.	Shop F. Value.
Machine shop	113	$99,043	160	$133,816	178	$196,400
Tin and pipe shop (includes bench tools)	20	2,700	42	630	55	850
Boiler and tank shop (includes furnaces, clamps, etc.)	23	21,327	23	24,450	24	48,580
Blacksmith shop (includes hammers, etc., but not forges)	13	11,957	12	15,450	25	18,500
Planing mill	57	12,383		None.		None.
Total	226	$147,410	237	$174,346	282	$264,330
Five per cent. of total	..	7,370	..	8,717	..	13,216

	Shop A.	Shop B.	Shop C.	Shop D.	Shop E.	Shop F.
Shop holds — Locomotives	5	9	16	22	22	50
Capacity — Locomotives a year	60	120	216	300	300	600
Area locomotive erecting shop, sq. ft.	..	13,163	19,688	30,000	26,532	85,854
Area machine shop, sq. ft.	..	20,837	19,687	44,600	44,220	74,605
Area boiler and tank shop, sq. ft.	..	13,320	22,620	56,730	25,232	77,503
Area — Total three shops, sq. ft.	..	47,320	61,995	131,330	95,984	237,962

By referring to the list of shops you will see that a railroad owning 200 locomotives can maintain its shop equipment in efficient condition by an annual appropriation of about $7,000, while $17,000 and $30,000 would be ample to keep up-to-date the shops of roads having respectively 600 and 1,200 locomotives. This 5 per cent. annual appropriation should not be expected to cover tools for new shops which have to be built on account of extending the road or making large additions to the rolling stock, although it might in some cases be possible to apply a part of it to such improvements. When a new shop is built and equipped the 5 per cent, annual appropriation should be allowed to accumulate until the money will earn 10 per cent. by replacing those machines which have become unprofitable to continue in use on account of wear or because of more efficient machinery having been designed.

I would advise bunching the valuation of the machinery in all the shops on any one road and applying the 5 per cent. per annum of the total for improvements in those shops where it would do the most good. This would be much better than to confine the 5 per cent. appropriation to each individual shop or sub-shop. Those tools should first be replaced which are most unprofitable to continue in service, and in buying new tools those should be selected which will effect the largest earnings. I have observed many instances where this has not been done; for example, instead of buying ordinary engine lathes, it would be more profitable for most shops to buy turret lathes, vertical boring and turning mills, automatic stud machines, milling machines, etc. Milling machines are more efficient for some work than planers and it is possible to do a great variety of work in drill presses which was formerly done in lathes and boring machines. A modern steel tired car-wheel lathe will turn out six pairs of wheels a day while some of the older machines turn out only three or less, which represents a saving by the new machine of about $2.50 per day or earnings of 20 per cent. on the investment. Modern turret lathes will do from two to five times more work than an ordinary engine lathe, and automatic stud machines will reduce the cost of studs from $2 or $3 per hundred to about $1 per hundred. Vertical boring and turnings mills will do at least double the amount of work that is possible on an engine lathe and occupy much less shop room.

Old stationary engines are often very wasteful. I remember one instance where an old engine operating a planing mill was replaced with a new one, and as soon as the latter was installed the output of the shop was increased fully 20 per cent., and the new engine, although of higher horsepower, was found to use less steam than the old one.

In most railroad shops the benefits to be derived from using high speed tool steels are largely nullified by old and light machinery.

Mr. J. M. Gledhill, in a paper presented at the October, 1904, meeting of the Iron and Steel Institute, gave some interesting examples of the work which is made possible by using high-speed tool steel. In one example a 12-inch lathe of special design and strength for rapid and heavy cutting, turned from a rolled steel bar 40 large bolts in 10 hours, removing 1¼ *tons* of metal at a speed of 160 ft. a minute, thereby saving all forging, and finishing five times as many bolts as were formerly turned by self-hardening steel in an ordinary lathe. "In fact, the cost of forging one bolt alone (formerly) amounted to more than the present cost of producing to required form 12 such bolts by high-speed machinery." In speaking of planers, he says: "The old cutting speeds of 15 to 25. ft. per minute are now replaced by those of 50 to 60 and even 80 ft. per minute, and * * * the power absorbed does not increase in anything like the same proportion as the extra amount of work done, so that the wear and tear on the machine is not materially increased." But it is safe to say that not one railroad shop in ten has a single lathe or planer capable of exerting the power and speeds which Mr. Gledhill cites as necessary to obtain the greatest economy from high-speed tool steel.

The importance of well equipped tool rooms in railroad shops seems to be very generally overlooked, and I have observed that those shops which are best managed and which turn out the largest number of locomotives in proportion to their size and the amount of machinery, are the ones which have excellent tool rooms and first-class men in charge of them.

There are railroad shops where labor unions have strongly opposed the introduction of labor-saving tools, but this is very unwise on the part of the unions, as it is on a par with the efforts made years ago to prevent the stage coach from being replaced with railroads and the old hand printing presses from being thrown out to make room for the modern power presses; in fact, this policy is a relic of the Dark Ages and should not be encouraged or tolerated. There is no occasion, whatever, for any skilled mechanic, whether union or non-union, to be alarmed about a scarcity of work, as the demand for skilled mechanics is greater than ever before. Furthermore, such efforts are bound to fail, as there is no instance in history where men have finally succeeded in opposing the march of Progress and the introduction of modern labor-saving inventions.

Two things are especially necessary in a locomotive repair shop to make the work move briskly; namely, the machine work must be turned out promptly and in sufficient quantity, and the boiler work must not be allowed to drag and delay the erecting gangs. In order to obtain these results, the equipment of the machine and boiler shops must be maintained in a high state of efficiency.

Most railroad companies go on buying engines and cars and increasing their size, but are slow to appreciate that their shops are no larger and the machinery not as good as 10 or 20 years ago when the cars and locomotives were smaller and less numerous.

Have you ever stopped to think of the amount of machinery that could be bought with the purchase price of one locomotive? Or has it ever occurred to you that if your company would reduce its last order for locomotives by one or two and use the amount so realized for new shop machinery the returns on the investment would be greater and would give more than an equivalent in engines by increasing the output of the shops and decreasing the length of time each locomotive must be held under repairs?

It is far more profitable for any railroad company to have small or medium-sized shops well equipped to crowd the work and overhaul engines promptly, than to have larger shops not so well equipped in which engines must be held from 30 to 40 days each for repairs. Take, for example, two railroads, each having shops with a capacity for overhauling 50 engines a month, one of which keeps under repairs 23 engines at a time, and is thoroughly well supplied with up-to-date machinery, so that the average time each locomotive is held in the shop for general repairs does not exceed 14 days; but the other shop, which keeps 50 engines under repairs at all times, is not so well equipped, and they are held 30 days each. The road owning the smaller well-equipped shop will have out of service for repairs but 23 engines at a time, while the company having the larger shop, not so well equipped, must keep 50 engines in the shop all the time to obtain the same output—50 locomotives a month. Therefore, the latter road will lose the service of 27 locomotives which the former has available for use, representing at a rental of $15 a day, a loss of $405 a day, or $147,825 a year. This a fair comparison, based on results obtained in actual shops.

Will it not pay every railroad company to adopt a plan for systematically maintaining its shop machinery in a high state of efficiency?

CONVENTION EXHIBITS AT MANHATTAN BEACH.—Copies of diagrams of the exhibit spaces, available at the Master Mechanics' and Master Car Builders' conventions in June have been received from Mr. J. Alexander Brown, secretary of the executive committee of the Railway Supply Men. Information concerning space may be obtained from Mr. Brown, 24 Park Place, New York.

SIX-COUPLED PASSENGER LOCOMOTIVE.

4—6—2 Type—Chicago, Milwaukee & St. Paul Railway.

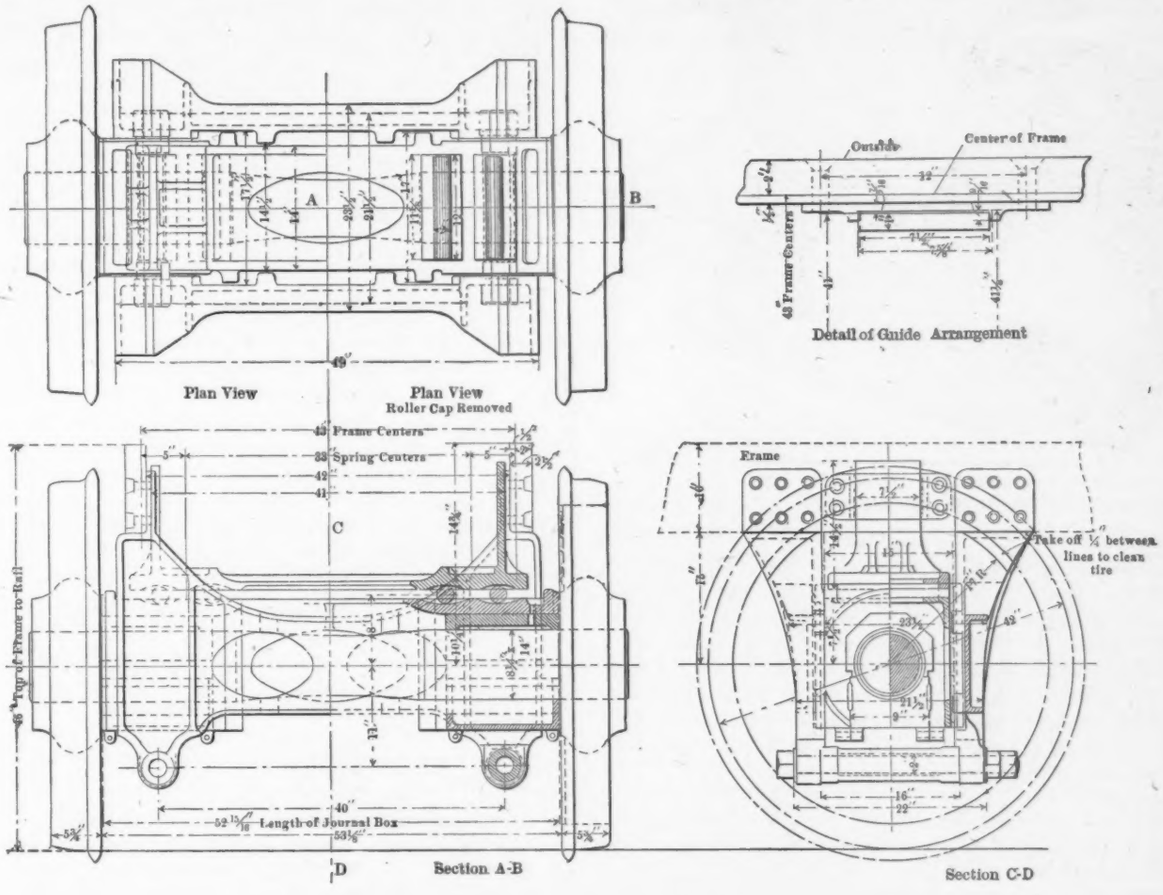
This locomotive was illustrated by a photograph on page 74 of the March number. It constitutes a departure in several respects from current practice, particularly in the narrow firebox and in the unusual cylinder proportions of 23 by 26 ins. Mr. Manchester believes the narrow firebox to possess advantages over wider ones, and is sure, from the performance of this engine, that he is correct. The tubes are much shorter than current practice in this type, and the cylinders were designed to obtain the best possible advantage in starting. Mr. De Voy, mechanical engineer of the road, has employed a ratio of 4.17 to 1 in simple freight engines, giving the same starting power as was obtained from compounds in use on this road, which have the advantage of boiler steam in the low-pressure cylinders.

The fifth design for locomotives of this road has been started by Mr. De Voy in accordance with a plan whereby the road is building all of its own locomotives. These designs are for a 19 x 26-in. switcher, a 22 by 28-in. consolidation, a 21 by 30-in., ten-wheel freight locomotive, the 23 by 26-in. Pacific type, and a ten-wheel passenger locomotive for the Kansas City division. The last-mentioned design is not yet completed.

Mr. De Voy has developed a new lateral motion, trailing truck for the Pacific type locomotive, which is, apparently, of the simplest possible construction, and is particularly novel because its principal parts are only four in number. This truck provides a lateral motion of 5 ins., and does not employ a radius bar or anything to give a radial motion. It is simply a pair of 8½ by 14-in. journal boxes placed between two jaws, the centering device being in the form of rollers. The designer has furnished a detailed statement of the cost of the truck, which is probably 50 per cent. cheaper than any form previously used and at the same time it is of strong construction.

The drawings selected for illustration show its construction clearly. The wheels are of cast steel, with spokes, and with cast iron hub liners pressed into the hubs. They are 42 ins. in diameter. The boxes are carried in a casting covering the axle between the hubs and mounted between the pedestal castings. These castings are bolted to the frames, and, incidentally, they furnish a deep brace for the rear ends of the frames. A roller cap rests on two 2 by 11⅞-in. hardened steel rollers at each end, and this casting is provided with vertical brackets or lugs, engaging guide castings, which are bolted to the inside faces of the frames. This is absolutely all there is to the truck. It is reported to be entirely satisfactory in service.

The roller cap of the truck receives the load through semi-elliptic springs over the boxes, and these connect with longitudinal equalizers, the fulcrums of which are under the firebox pads. At their front ends these equalizers connect with the ends of a transverse equalizer extending across the engine in front of the ash pan.



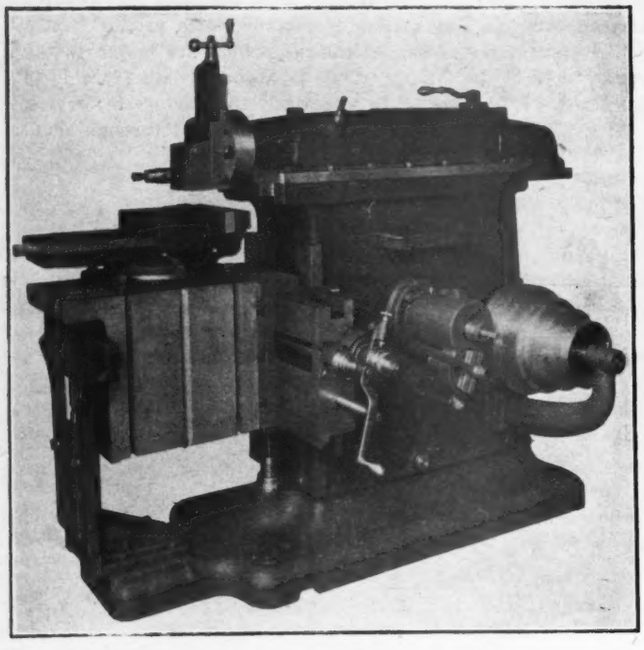
Lateral motion trailing truck for 4—6—2 type locomotive.
Chicago, Milwaukee & St. Paul Railway.

24-INCH BACK GEARED CRANK SHAPER.

The designers of the 24-in. crank shaper, illustrated in the photograph, seem to have fully understood the question of distributing the metal to the best possible advantage in order to gain strength and rigidity and also the importance of having all adjustable parts convenient to the operator and easy of adjustment. The column is of large proportions and is reinforced where the working strains are greatest. The ram gradually increases in section so that the maximum or strongest section comes into use when the cutting tool is at its extreme forward position. It has a 40 x 11-in. bearing on the column. The length of the stroke and the position of the ram may be changed without leaving the work and while the tool is at

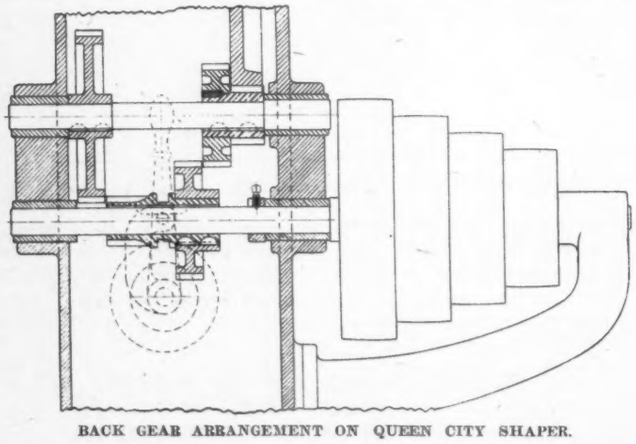
rest or in motion. A large opening under the ram provides for key seating shafts. The rocker arm is connected to the ram by means of a link which allows a straight pull and an even cutting speed, with a very quick return and no lost motion. This construction was illustrated in connection with the 16-in shaper described on page 445 of our November, 1904, journal, and the adjustment to compensate for the wear of the crank shoe was also shown.

The ratio of the back gearing is 29 to 1. A change from one



QUEEN CITY BACK GEARED CRANK SHAPER.

run of gearing to the other is made by means of a lever which operates the sliding gears on the driving shaft, as shown on the drawing. The rail is very heavy and has ample wearing surfaces. The cross traverse is 30 ins. and the screw has a graduated collar. The vertical adjustment is effected by bevel gears which are protected from chips and dust and are provided with ball bearings. A cam provides for the rapid changing of feeds without stopping the machine. The table is box form, T slotted on the top and the sides and has a V for hold-



BACK GEAR ARRANGEMENT ON QUEEN CITY SHAPER.

ing shafts and similar work vertically. It is arranged with an outer support and may readily be detached from the saddle if desired. The vise is of the planer type and its base is firmly bolted to the table; the swivel is held to this base by two steel planer head bolts. The head swivel is held in the same manner; both are graduated, and can be set at any angle, quickly and accurately. The down feed screw to the head is provided with a graduated collar. This machine is made by the Queen City Machine Tool Company, Cincinnati, Ohio, and weighs about 4,400 lbs.

A RAILROAD OFFICIAL WANTS CATALOGUES.

To the Editor:

Having been appointed general manager of the Compania del Ferrocarril de Matanzas, please state in your paper that I shall be glad to receive all kinds of catalogues and samples from firms dealing in railroad supplies and materials, addressed to me at Matanzas, Cuba.

MIGUEL C. PALMER.

WATER SOFTENING.

CONTROL AND RESULTS FROM A CHEMICAL STANDPOINT.

BY G. M. CAMPBELL, P. & L. E. R. R.

(*Continued from page* 88.)

Thus far this article has covered in a general way the system of control of the plants on the Pittsburgh & Lake Erie Railroad, and the chemical, and a few of the general, results derived therefrom. Attention will now be drawn to the more or less technical side of the treatment and the inferences to be drawn from the results.

The solutions used in testing are fiftieth normal sulphuric acid, fiftieth normal sodium hydrate, standard soap solution, methylorange indicator, one gram per liter, and phenolphthalein indicator, 5 grams per liter. The amounts of water used are such that one C.C. of the solution represents in every case the equivalent of one part of calcium carbonate per 100,000, and is called 1 deg. (this is equivalent to 0.584 grains per gal.). The "alkalinity" of any sample represents the sum of the carbonates, bicarbonates and the alkaline hydrates. The acidity, to methylorange as indicator, represents in most cases the true or free acidity of the water other than carbonic acid; the acidity to phenolphthalein as indicator, when the water is alkaline to methylorange as indicator, represents the free carbonic acid; when the water is acid to methylorange it represents all the free carbonic acid and twice the free or partly combined mineral or other acid. The relation the various tests bear to the charging may be found in the instructions for testing and treating, Tables 1 and 2. The main equations of water treating may be stated as follows:

(1) Bicarbonate of lime $CaH_2(CO_3)_2$ Soluble + Caustic lime CaO Soluble = Carbonate of lime $2CaCO_3$ Insoluble + Water H_2O

(2) Sulphate of lime $CaSO_4$ Soluble + Carbonate of soda Na_2CO_3 Soluble = Carbonate of lime $CaCO_3$ Insoluble + Sulphate of soda Na_2SO_4 Soluble

(3) Bicarbonate of magnesia $MgH_2(CO_3)_2$ Soluble + Caustic lime CaO Soluble = Carbonate of magnesia $MgCO_3$ Slightly sol. + Carbonate of lime $CaCO_3$ Insoluble + Water H_2O

(4) Sulphate of magnesium $MgSO_4$ Soluble + Carbonate of soda Na_2CO_3 Soluble = Carbonate of magnesium $MgCO_3$ Slightly sol. + Sulphate of soda Na_2SO_4 Soluble

(5) Carbonate of magnesia $MgCO_3$ Slightly sol. + Caustic lime CaO Soluble + Water H_2O Water = Hydrate of magnesia $Mg(OH)_2$ Insoluble + Carbonate of lime $CaCO_3$ Insoluble

(6) Carbonic acid H_2CO_3 Soluble + Caustic lime CaO Soluble = Carbonate of lime $CaCO_3$ Insoluble + Water H_2O

(7) Sulphuric acid H_2SO_4 Soluble + Carbonate of soda Na_2CO_3 Soluble = Sulphate of soda Na_2SO_4 Soluble + Carbonic acid H_2CO_3 Soluble

There is, among chemists, considerable discussion as to how the various impurities in water should be expressed, whether sulphuric acid, for example, should be expressed as H_2SO_4, as above, or as its radical, SO_3. Caustic lime, CaO, is used in the above equation; it would perhaps be better to use slaked lime Ca $(OH)_2$, but the former is retained to make the calculation for weight of lime required easier. It is rarely possible to determine the exact relation of the elements in the water. But the discussion as to the exact relation is of little importance here as the treatment is not based directly on the reactions, as given, but on the general statement that one part

of calcium sulphate or magnesium chloride, for example, not directly as such, but in whatever form it actually exists, requires one part soda. But the equations are useful just as a general method of expressing the reactions that occur. These equations need not be discussed in detail; in general sulphates, chlorides, etc., of calcium require an equivalent amount of soda ash, carbonate of soda, as in (2); bicarbonates of calcium require lime as in (1). Sulphates, chlorides, etc., of magnesium require an equivalent amount of soda ash and an equivalent amount of lime as in (4) and (5). Bicarbonates of magnesium require two equivalent parts of lime, as in (3) and (5). In most waters the bicarbonates of lime and magnesia are represented by the alkalinity. Carbonic acid is removed by lime, as in (6). Mineral acid, such as sulphuric, requires both soda ash and lime, as in (7) and (6). Carbonate of lime and hydrate of magnesia are marked "insoluble." That term is only relative. The former, freshly precipitated, is soluble to about 5 parts per 100,000, and the latter to 2 parts per 100,000. Magnesium carbonate is marked "slightly soluble," that term also is only relative; as far as treated water is concerned, it is soluble, for about 50 parts per 100,000 may be dissolved, which is far beyond the amount allowed in treated water. For each 1 deg. of alkalinity 1 part of lime is required; by one part is meant that amount of lime which is chemically equivalent to one part of calcium carbonate per 100,000, this amount is 0.56 pounds of pure lime for each one pound of calcium carbonate, or 0.66 pounds of 85 per cent. lime. The amount of 85 per cent. lime required to treat 1,000 gals. of water, or 8,330 lbs., for each 1 deg. alkalinity would be

$$0.66 \times \frac{1}{100{,}000} \times (1{,}000 \times 8.33) = 0.055 \text{ lbs.}$$

Similarly, one part of lime is required for each part of acid present, whether it is carbonic acid or mineral acid. In order to dissolve this amount of lime, 0.055 pounds, it is necessary to supply from 38 to 45 pounds, or from 4.5 to 5.4 gals. of water. The amount of water depends to a certain extent on the temperature, the solubility of lime decreasing as the temperature of the water increases. In a machine where there is always an equal head of water over the raw water and lime pipe slots, the proper supply of lime water is easily obtained by making the area of the adjustable opening in the lime pipe equal to 0.0045 to 0.0054 of the raw water slot for each 1 deg., i. e., make the areas proportionate to delivery. In practice, this area has to be slightly increased, to from 0.005 to 0.006 of the raw water slot. The permanent hardness is the difference between the total hardness and the temporary hardness or alkalinity. For each degree of permanent hardness 1 part of soda is required; this amounts to 1.06 lbs. of soda for each pound of permanent hardness present considered as calcium carbonate, or 1.116 lbs. of 95 per cent. soda. For 1,000 gals. this would be 0.093 lbs. of 95 per cent. soda for each degree of permanent hardness. Each degree of true acidity also requires 0.093 lbs. of soda per 1,000 gals. The presence of magnesium salts effects the amount of lime required; for each part of magnesium present one additional part of lime has to be added. The additional amount required may be easily found from experience, as the relative amount of magnesia in any water does not usually vary much, and it is useless to make elaborate laboratory tests to determine it. The average amount of lime used per deg. per 1,000 gals. treated, on the Pittsburgh & Lake Erie Railroad, is now about 0.056 lbs., this is somewhat under requirements; the average amount of soda is about 0.093 lbs., this is about correct.

On the weekly report sheet, Fig. 1, is a group of columns headed "Coagulant." In times of flood the rivers in the vicinity of Pittsburgh carry down an immense quantity of suspended matter, and at these times the water is very soft, often not more than 5 deg. hardness. Under such conditions there is practically no precipitate formed in the softener due to any chemical reaction, and only the heavier parts of the matter in suspension will settle, the balance will pass through the filter, giving a very turbid treated water. This is overcome by the addition of a coagulating material and a sufficient increase in the lime and soda to combine with all the coagulant added. The substances thus formed, in precipitating entangle the particles or mud with them, and so the water is clarified. It should be remembered that if the water is hard, from 10 deg. up, no coagulant is necessary no matter how much mud the water contains. It was found from experience that alum alone was entirely unsatisfactory, and ferrous sulphate, commonly called copperas, not very much better. A mixture of these substances in the ratio of about 4 pounds of ferrous sulphate to 1 pound of alum gave excellent results. On one occasion the water pumped at Pittsburgh contained about 4 per cent. by volume of mud; the treated water came out so clear that a newspaper could be read through 5 or 6 ins. of water. For each 1 lb. of the coagulant mixture, about 0.4 lbs. of soda and 0.25 lbs. of lime should be added, in addition to the amount required for treating the hardness, etc. Great care should be taken that there is sufficient soda and lime to react with all the alum and ferrous sulphate, otherwise a corrosive treated water will result. No definite rules have as yet been worked out as to the minimum amount of the coagulant that could be used; the amount will probably vary very much according to the kind of material in suspension. Very satisfactory results were obtained at Pittsburgh under severe conditions by the use of about ¾ lb. of the mixture per 1,000 gals.

The treated water is tested to determine whether or not the treatment is satisfactory. One additional test to those on the raw water is made, called "Causticity." This word was obtained from an article by Mr. A. McGill, in the *Journal of the Society of Chemical Industry*, April, 1904. With apologies to Mr. McGill, the word has been adopted, but with a somewhat different meaning. It is used in this article to mean the reading obtained in C.C. when 200 C.C. of the water are treated with fiftieth normal sulphuric acid with phenolphthalein as indicator, or, in other words, it represents alkalinity to phenolphthalein as indicator in parts per 100,000, figured as calcium carbonate. The causticity represents all the carbonates, twice the hydrates, but none of the bicarbonates. This reading may appear at first sight rather meaningless, yet it is very important, not to determine the exact condition of the water, but to determine the deficiency or excess in lime treatment. Representing hardness by H, alkalinity by A and Causticity by C, it may be proved—but the proof will not be here given, as it is a purely chemical one—that, within certain limits, in the treated water H—A = deficiency of soda and A—C = deficiency of lime; if A is greater than H there is A—H excess of soda; and if C is greater than A, C—A represents the excess of lime. Thus for each 1 deg. difference, H—A, the amount of additional 95 per cent. soda required would be 0.093 lb. for every 1,000 gals., and for each 1 deg. difference, A—C, 0.055 lb. of 85 per cent. lime. From these simple tests, treatment can be quickly and intelligently changed; but in water treating, as in everything else, it pays to make haste slowly; all other points, such as output of pumps, stoppage of supply pipes, etc., should first be investigated before any change is made in the charging tables. If it is found that the charges differ radically from the theoretical amounts above referred to, then investigation should be begun at once to find and remedy the trouble; such charges should not be allowed, even though satisfactory results are apparently obtained. There would probably be a waste of material, and probably, if the pumping rate changed, the quality of the treated water would fluctuate widely. The statements above in regard to supply of lime are not quite correct in waters containing magnesium salts. As stated before, in any water the relative proportion of magnesium salts does not usually vary to any extent, no matter how much the water as a whole varies. Consequently, the magnesia can be taken care of by obtaining experimentally the proportionate increase in lime above 0.055 lb. or by basing the proportionate increase on the full chemical analysis of a few picked samples. A method is now being developed to take care of

the magnesium directly by the regular tests, but it is not yet in shape for publication. The same holds true for acid waters; slight modifications in treatment may be made later.

For stationary plants the alkalinity should slightly exceed the hardness, and the causticity slightly exceed the alkalinity; but the latter difference should be as near zero as possible. For locomotive work it may be advisable, especially where such a device as the Raymer hot-water washing-out appliance is not in use, to keep the alkalinity slightly below the hardness and the causticity equal to or only very slightly above the alkalinity; the reason for this difference is the liability of the locomotive to foam and the increased tendency caused by the accumulative excess of soda.

In the system of tests here advocated it will probably be generally admitted that the alkalinity, acidity and causticity tests are fairly reliable, as they represent definite chemical reactions. Such, however, will rarely be admitted of the soap test. In fact, the soap test is usually looked upon as simply a rough approximation, and practically all chemists of note have so stated. Notwithstanding this adverse sentiment, the soap test, as used on the Pittsburgh & Lake Erie Railroad, has proved itself a thoroughly efficient and reliable test. Comparative tests have been made, several hundred in number, on waters of every description, with soap solutions of different strengths, and used with different quantities of water, one soap solution being the same as referred to in this article and the other made up strictly in accordance with Sutton's "Volumetric Analysis." In not one case was the difference as much as 1 part in 100,000, and in only six cases as great as ½ part in 100,000. As ½ part was the limit of accuracy aimed at, the readings were practically identical. Again, during the present year 27 samples of water were sent for full analyses, 19 to one of the best chemical laboratories in the country, the Pittsburgh Testing Laboratory, where water analysis has received great attention; the 8 other samples were analyzed by two different laboratories, both of high repute. Results obtained were as follows:

Sample No.	Full Analysis made by	Report No.	Parts per 100,000 as Calcium Carbonate. Hardness from Full Anal.	Hardness Soap Test, P. & L. E. Lab.	Diff.
1.	Pgh. Test. Lab.	21,660	19.28	18.8	— 0.48
2.	" " "	21,660	8.21	8.0	— 0.21
3.	" " "	21,661	42.08	41.4	— 0.68
4.	" " "	21,661	5.78	5.0	— 0.78
5.	" " "	21,662	4.96	5.5	+ 0.54
6.	" " "	21,662	5.12	5.0	— 0.12
7.	" " "	21,835	6.30	5.5	— 0.08
8.	" " "	21,905	55.74	55.0	— 0.74
9.	" " "	21,974	40.28	40.0	— 0.28
10.	" " "	22,066	21.20	21.3	+ 0.10
11.	" " "	22,178	93.40	88.0	— 5.40
12.	" " "	22,390	14.61	15.5	+ 0.89
13.	" " "	22,429	4.58	5.0	+ 0.42
14.	" " "	22,504	11.00	8.5	— 2.50
15.	" " "	22,898	28.38	* See note below.	
16.	" " "	22,899	6.36	5.75	— 0.61
17.	" " "	22,900	4.78	4.60	— 0 18
18.	" " "	22,982	45.97	*	
19.	" " "	22,982	2.49	1.50	—0.99
20.	Laboratory A		5.5	5.5	0.0
21.	Laboratory B	2,940	3.59	5.5	+ 1.91
22.	" "	3,031	38.1	37.0	—1.10
23.	" "	3,224	26.85	*	
24.	" "	3,223	6.27	5.75	— 0.52
25.	" "	3,225	4.44	4.60	+ 0.16
26.	" "	3,227	49.98	*	
27.	" "	3,226	1.68	1.5	— 0.16

Samples were as follows:

No. 1. Whitsett Junction, raw water, high in magnesium salts, collected April 9th, 1904.
No. 2. Whitsett Junction, treated water, collected April 9th, 1904.
No. 3. McKees Rocks, raw water, collected April 9th, 1904.
No. 4. McKees Rocks, treated water, collected April 9th, 1904.
No. 5. Buena Vista, raw water, collected April 9th, 1904.
No. 6. Buena Vista, treated water, collected April 9th, 1904.
No. 7. McKees Rocks, treated water, collected May 12th, 1904.
No. 8. No 3 stationary boiler, McKees Rocks, collected May 23d, 1904.
No. 9. Pittsburgh, raw water, collected June 9th, 1904.
No. 10. No. 3 stationary boiler, McKees Rocks, collected June 22d, 1904.
No. 11. Stationary boiler No. 6, McKees Rocks, collected July 27th, 1904.
No. 12. Beaver Falls, raw water, collected September 16th, 1904.
No. 13. Dickerson Run, raw water, collected September 24th, 1904.
No. 14. No. 2 stationary boiler, McKees Rocks, collected October 6th, 1904.
No. 15. Pittsburgh, raw river water, collected December 9th, 1904.
No. 16. Pittsburgh, treated water, collected December 9th, 1904.
No. 17. Groveton, treated water, collected December 9th, 1904.
No. 18. Buena Vista, raw river water, collected December 23d, 1904.
No. 19. Buena Vista, treated water, collected December 23d, 1904.
No. 20. Identical sample to No. 7.
No. 21. Identical sample to No. 7.
No. 22. Pittsburgh, raw well water, collected July 29th, 1904.
No. 23. Identical sample to No. 15.
No. 24. Identical sample to No. 16.
No. 25. Identical sample to No. 17.
No. 26. Identical sample to No. 18.
No. 27. Identical sample to No. 19.

These are a complete list of all waters analyzed to date on which parallel tests had been made, and are, therefore, not analyses picked to prove a theory.

*The two samples, 15 and 18, and their duplicates, 23 and 26, were acid waters, and the hardness tests made in the P. & L. E. R. R. laboratory can hardly be directly compared with the tests in the outside chemical laboratory. The hardness obtained in the P. & L. E. R. R. laboratory was on water neutralized to methylorange as indicator. By referring to Tables 1 and 2, it will be noted that in acid waters the charge is based on the hardness of neutralized water plus the acidity, both with reference to methylorange as indicator. For Samples Nos. 15 and 23 the P. & L. E. R. R. tests were hardness, neutralized water, 23.5; acidity, 1.5; total, for soda treatment, 25.0. Pittsburgh Testing Laboratory gave, for the same water, hardness, 22.62; and free sulphuric acid, 5.76 (considered as equivalent parts of calcium carbonate), a total of 28.38. Laboratory B gave hardness of 25.45 and free sulphuric acid 1.40, a total of 26.85. From the results obtained in P. & L. E. R. R. laboratory, and in comparison with Laboratory B, the large amount, 5.76, of free sulphuric acid given by Pittsburgh Testing Laboratory is incorrect. For Samples Nos. 18 and 26, P. & L. E. R. R. tests gave hardness, neutralized water, 32.0; acidity, 15.0; a total, for soda treatment, of 47.0. Pittsburgh Testing Laboratory gave hardness 36.33; free sulphuric acid, 9.64; a total, for soda treatment, of 45.97. Laboratory B gave hardness, 38.70, and free sulphuric acid, 11.28; a total of 49.98.

The samples tested were very varying in character, soft and hard, treated and untreated, unused and water from boilers, etc. It will be noted that, omitting Samples 15 and 18 for reasons given above, of the other 17 samples sent to Pittsburgh Testing Laboratory, the hardness as given by P. & L. E. R. R. soap test differed from that given by a full analyses by as much as 1 part in 100,000 only in Nos. 11 and 14. Both of these were boiler waters, and were extremely high in soluble sodium salts. Sample No. 19, though an unused water, was also high in soluble salts, containing about 85 parts per 100,000. These soluble salts probably affected the soap readings. Of the other 15 samples, mostly of raw or treated unused waters, in not one case was the difference between the P. & L. E. R. R. soap test hardness and that obtained by the laboratory analysis as great as 1 part per 100,000. On the other hand, attention may be drawn to the difference of 2.71 between the chemical laboratories in identical Samples Nos. 7 and 21. Laboratory A in No. 20 gave for the same water an intermediate value identical with the P. & L. E. R. R. soap test. The difference between the Pittsburgh Testing Laboratory and Laboratory B in Samples Nos. 15 and 23 is 1.53; in Nos. 16 and 24, 0.09; in Nos. 17 and 25, 0.34; in Nos. 18 and 26, 4.01; in Nos. 19 and 27, 0.81.

It is not here claimed that the soap test is an absolutely correct method of determining hardness, but it is claimed that for purposes of water softening it is perfectly reliable and will give uniformly consistent results. The variation of 1 part per 100,000, even though it is a high percentage of a low hardness, is immaterial.

A sample of water of no matter what hardness, within reasonable limits, can be taken, and repeated tests for hardness by the soap test will give identical results or almost so, and after a short experience the results obtained by any water softener attendant are almost identical with those obtained by the more expert chemist in the laboratory. It requires only a small experience to distinguish and avoid the false lather made by magnesium salts. On the other hand, the discrepancy between two different laboratories is often very marked. The accuracy and reliability of the soap test is vital to the general system of treating set forth in this article, and from

statistics such as the above, it would seem that it is deserving of the highest confidence.

The value of any system of treatment must necessarily be judged by results. After the introduction of the "clear indicator" (phenolphthalein) tests in June, 1904, the results obtained were excellent. At this time, February, 1905, practically identical formulæ are in force at all points, no matter what the source of supply or what the quality of the water, and the resulting waters are almost identical, except, of course, in the amount of soluble sodium salts. At four of the plants there are two sources of supply, each differing radically in quality. Each source may be and has been used several times in a week, and yet the resulting treated water remained practically constant.

If, then, waters of widely varying quality, whether well water or pond water or water from half a dozen different rivers, if radically different waters from different sources, can be used in the same softener, alternating even daily, if one and the same softener can satisfactorily treat water varying from 5 to 60 deg. in hardness and from an alkaline to an acid water, if all these varying conditions can be handled at all points by identical treatment per degree per 1,000 gals., and if almost identical results can be obtained in regard to hardness, alkalinity and causticity, and since these conditions and results do exist on the Pittsburgh & Lake Erie Railroad, then it seems a fair assumption that the theory of the treatment here advocated and employed is worthy of confidence, that the method of control is efficient and easy of operation, and that water softening, in a softener of good design, can be satisfactorily handled by ordinary workmen who have absolutely no knowledge of chemistry.

On account of the confidence placed in the system of testing, advocated in this article, it was not thought necessary to have any complete analyses made of water at water softening points between June and December, 1904, and then only of a few waters for record purposes. The confidence placed in the system of testing is shown by the fact that water from six out of the ten softeners—Williamsburg, Groveton, Stobo, Rock Point, New Castle Junction and Haselton—all variable waters, has not yet been analyzed, but at the same time there is no doubt whatever about the quality of the treated water.

Some of the samples in the early part of the year are not satisfactory according to present standards. It was not until June that a full system of tests was used, and it was somewhat later before proper adjustments were obtained, owing to some mechanical changes being made in the softeners.

Many sample analyses cannot be given, for the reason that they have not been made; nor are they necessary, for the approximate analyses, as obtained by the system of tests as outlined in this article, give all the required information, and besides give a very close estimate of the exact substances in the water. Information along this line will be published later. As samples, however, of the results obtained, raw and treated waters from Buena Vista, Nos. 18 and 19, and treated water from Groveton, Sample No. 25, are given below; the latter sample is a sample of treated water from raw water, of which no full analysis has yet been made, and yet a better treated water it would be hard to obtain.

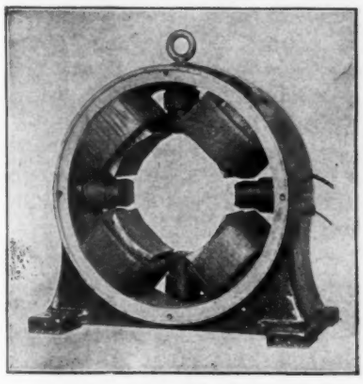
Sample No. 13. Buena Vista Raw and Treated Water.

	Parts per 100,000. Raw.	Treated.
Silica	0.88	0.52
Sulphate of alumina	12.54	0
Sulphate of iron	5.43	0
Carbonate of lime	0	0.89
Carbonate of magnesia	0	1.34
Carbonate of soda	0	4.35
Sulphate of soda	9.00	75.30
Sulphate of lime	22.27	0
Sulphate of magnesia	6.45	0
Chloride of soda	2.97	3.13
Free sulphuric acid	9.44	0

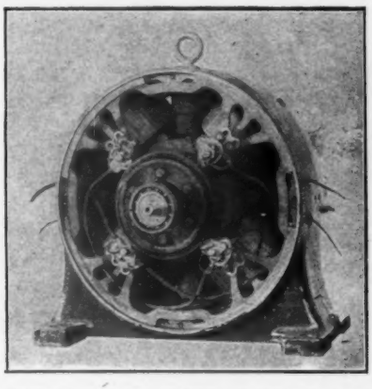
Sample No. 25. Groveton Treated Water.

	Parts per 100,000.
Calcium carbonate	2.49
Calcium sulphate	0
Calcium chloride	0
Magnesium carbonate	1.51
Magnesium sulphate	0
Magnesium chloride	0
Iron and alumina	0.21
Silica	0.65
Suspended matter	0
Sodium sulphate	12.65
Sodium chloride	6.02
Sodium carbonate	0.46
Sodium nitrate	0
Carbonic acid	0

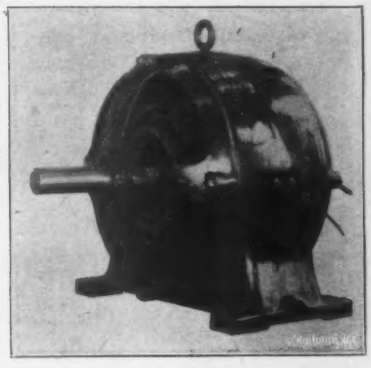
The softeners, laboratory, records, and general system on the Pittsburgh & Lake Erie Railroad are open for inspection to any one desiring information along these lines.



FRAME OF MOTOR SHOWING MAIN AND INTERPOSED POLES.



MOTOR WITH FRONT REMOVED AND ARMATURE BRUSH HOLDER RING, WITH BRUSHES IN POSITION.



THE COMPLETE INTERPOLE MOTOR.

INTERPOLE VARIABLE SPEED MOTOR.

The value of the variable speed motor for machine tool drives is indicated by the growing demand for such motors and by the improvements and new designs which are being brought out from time to time. The most recent type of this motor which can be operated on a single voltage is known as the interpole variable speed motor, and the following advantages are claimed for it: Wide range of speed, non-sparking under overloads as high as 100 per cent., practically constant speed under any load for any controller point when once adjusted, it may be reversed under full load and will run equally well in either direction, compactness of design, light weight and high efficiency at all speeds.

The auxiliary poles, which are quite small compared to the main poles, as will be noted by reference to the photograph, are located between them, and are provided with coils connected in series with the armature, so that all of the current taken by the armature flows through the coils of the auxiliary field, which are so proportioned and arranged as to give the proper field for commutation. Weakening of the field of commutation by an increased load is thus prevented, and the auxiliary poles produce the required compensatory field of commutation independently of the main field, which, with an increased number of revolutions of the armature, must be correspondingly weakened. Sparking due to armature re-

action and to self-induction in the armature coils, which are short-circuited at the instant that their corresponding commutator segments pass under the brush, is thus avoided, and it is not necessary to shift the brushes in order to reverse the motor.

The torque of these motors increases as the speed decreases, and the horse-power capacity is therefore not effected by the speed. The construction is simple, and, owing to the absence of sparking, the cost of maintenance should be low. The field yoke or frame is of cast steel. The armature shaft is of large diameter, and is fitted with Hess-Bright ball bearings. One ball race is pressed on the end of the armature shaft and the other fits in the bearing housing. The balls are separated by springs. This type of ball bearing has been in use on motors in Europe for three years with excellent results. By their use friction is greatly reduced, the length of the motor may be made much less than where the ordinary type of bearing is used, and as vaseline is used for lubrication, there is no danger of getting oil on the commutator and coils.

The construction and lubrication of the motor are such that it can be placed in any position. The speed range ordinarily furnished is either 2, 3 or 4 to 1, but greater variation can be provided, if desired. These motors are made by the Electro-Dynamic Company of Bayonne, N. J.

LOCOMOTIVE DRIFTING VALVE.

WABASH RAILROAD.

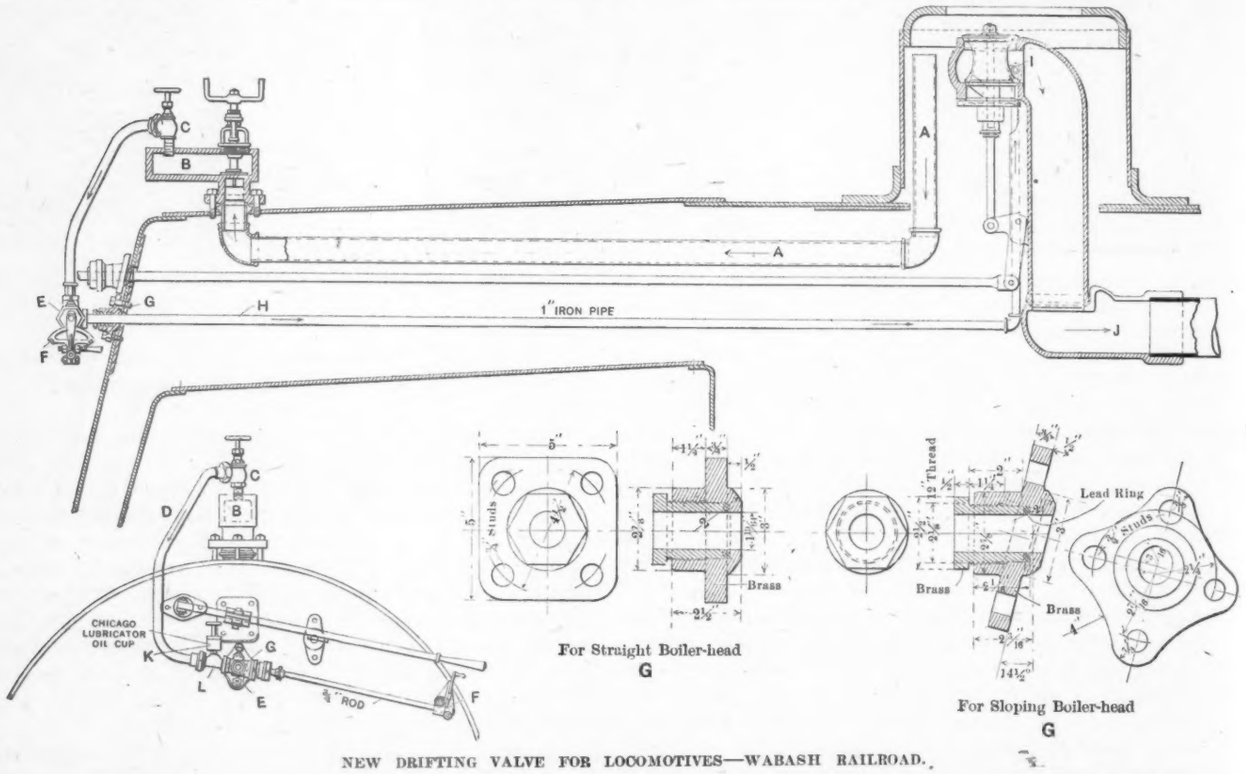
This device was developed to prevent the formation of vacuum, and compression when drifting and incidentally to improve lubrication and reduce repairs. It has been in service for a year and has been applied to more than 150 Wabash locomotives. Relief valves on slide valve engines and by-pass valves on compounds and piston valve engines have been discarded. The effect of the drifting valve on the wear of brasses has been marked. Its effect in reducing cylinder retardation in drifting is also marked. This device is also fitted with an oil cup attachment whereby the valves and cylinders may be lubricated in case of a failure of the regular lubricating cup or the attachment may be used for introducing graphite.

In the engravings A is a steam pipe leading from the steam dome to turret B, to which is attached a globe valve C, connecting with a drifting valve E by pipe D. Valve E is operated by a handle working in quadrant F, which opens or shuts valve E. To valve E is attached pipe H, running through stuffing box G. Pipe H is connected with the throttle box at I. The object is to take dry steam from the dome, as indicated by the arrows, and introduce it into the cylinders through the connections mentioned and dry pipe J. Globe valve C regulates the supply of steam from turret B and the engineer controls the steam by handle F through the drifting valve E. When the engine is running or drifting with the throttle valve closed, the position of the reverse lever need not be disturbed. While the engine is in motion the drifting valve is open and when the engine is standing at stations the valve is shut. The operation of this valve relieves compression, it destroys vacuum, keeps the engine running smoothly without reaction, making a great reduction in repairs. The suction of smoke and cinders into the steam chests and cylinders and the consequent cutting of valve seats and cylinders is corrected. It is also reported to prevent the metallic packing from being knocked down and broken.

An oil cup K is used for oiling the main valves of the locomotive while drifting in case of failure of the lubricator. To operate the cup, close valve C and open cup K and oil will be drawn into the steam chests and cylinders by suction.

While the engine is standing, the valve C is closed, the cup K opened and the pipe H filled with oil, then cup K is closed, the valve C opened and oil will be immediately carried into the steam chests and valves by steam pressure from the boiler. L is a nipple providing a convenient place for the attachment of the cup K, being so designed that the oil cup may be always tapped in vertically.

This information was furnished by Mr. J. B. Barnes, superintendent of motive power of the Wabash Railroad.



NEW DRIFTING VALVE FOR LOCOMOTIVES—WABASH RAILROAD.

PLANER WITH PNEUMATIC REVERSING MECHANISM.

The belt shifting mechanism has not proved very successful for reversing the platen on the larger planers, especially since higher cutting and return speeds have been attempted. The 96 in. by 96 in. by 20 ft. Sellers' planer, illustrated herewith, weighs 60 tons, has a cutting speed varying from 15 ft. to 45 ft. a minute, a constant return speed of 80 ft. a minute, and is equipped with a pneumatic reversing mechanism, which does away with the belt shifting mechanism, affords a quick

and uniform reverse and reduces the loss of power at reversal due to the inertia of the rotating parts. The planer is driven by a 50-h.p. motor placed on a cast iron platform supported by brackets on the housings. It is provided with two cutting tools on the cross rail and one on each of the housings. Each of the two saddles has its own feed motion, independent-

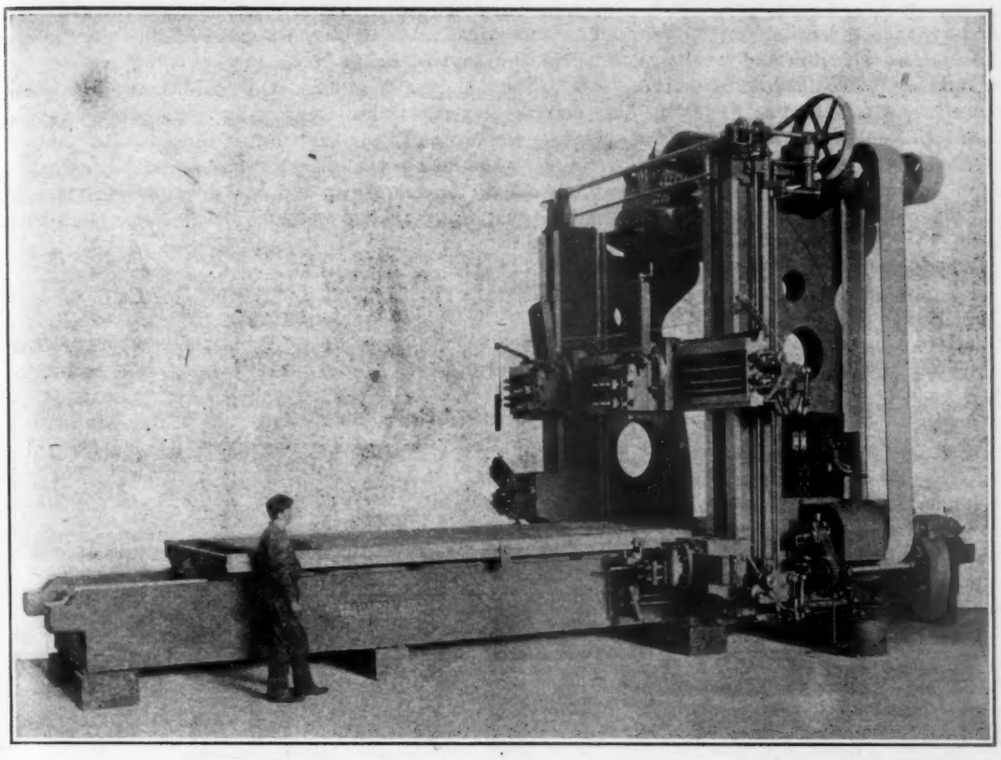


FIG. 1.—SELLERS' PLANER, WITH PNEUMATIC REVERSING MECHANISM.

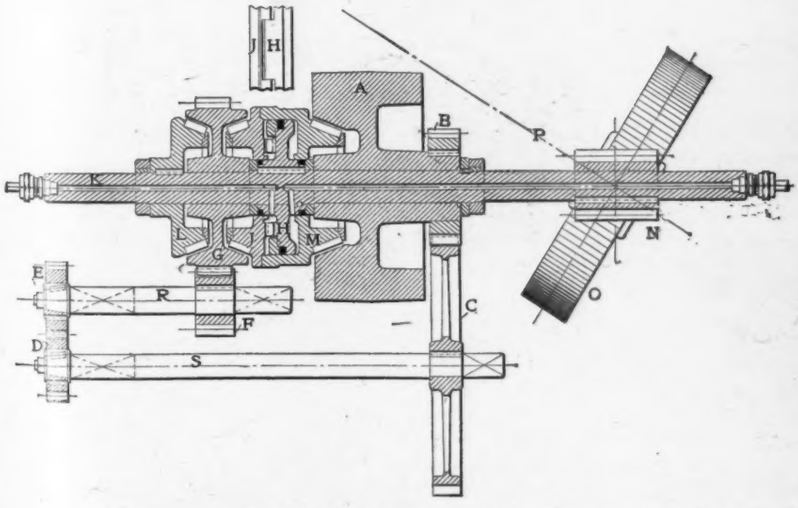
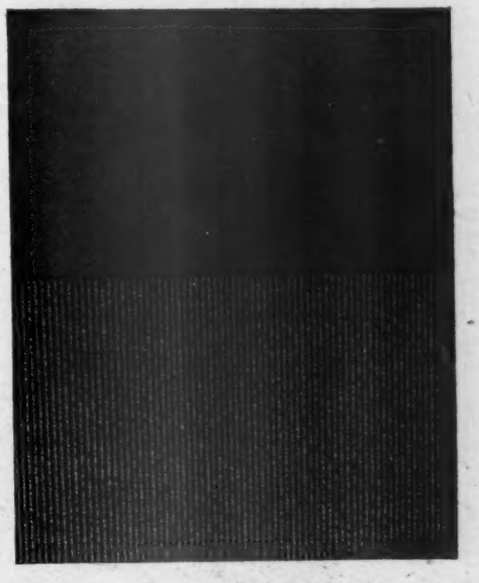


FIG. 2.—SECTIONAL VIEW, SHOWING DRIVING AND REVERSING MECHANISM.



SAMPLE OF PLANING, SHOWING UNIFORMITY OF REVERSE.

ly adjustable in direction and amount. Each has also its own stopping and starting device, but the planer is so arranged that all of these may be thrown out of action or into action simultaneously by the motion of a hand lever, and this may be done from either side of the planer. The table is supported in one flat and one V-bearing, which are lubricated by oil under pressure instead of through rollers or wipers. The oil is circulated through a piping system by a pump, and returns to the oil tank through filters. The V-bearing has four surfaces, two forming a V of large angle sufficiently inclined to guide the table under ordinary circumstances, but having the minimum wedging action. The other two surfaces are nearly vertical, and do not bear under ordinary circumstances, but are ready to resist side cuts which are sufficiently heavy to slide the table up on the V. This arrangement permits the table to run lightly under ordinary work, but prevents it from lifting under any condition of heavy side cutting.

Details of the clutch and driving mechanism are shown in Fig. 2. A spiral pinion on the shaft P drives the table. The spur gear C on the outer end of shaft P is driven by the spiral pinion N on the pulley shaft. The driving pulley A runs loose on the shaft K, and is driven continuously and in the same direction while the planer is in operation. Pinion B, which is keyed to the hub of pulley A, drives through gears C, D, E and F the gear G, which runs loose on the shaft K and in the opposite direction from pulley A. J and M are bolted together, forming an air-tight cylinder, free to move back and forth on the disk H, which is keyed and pinned to the shaft K. To compel the shafts to rotate with the friction clutch the head of the cylinder J is provided with notches into which teeth on the surface of the piston H project. These form a jaw clutch, and permit end movement while they compel the parts to move together.

Air admitted to one end of the cylinder through the center of the shaft K, between the parts H and M, causes the cylinder to move in the direction of the pulley A, pressing the friction cone against the pulley, so that the clutch rotates with the pulley. This movement is transmitted through the piston H by the clutch teeth, and causes the shaft to rotate in the same direction, which gives the return movement of

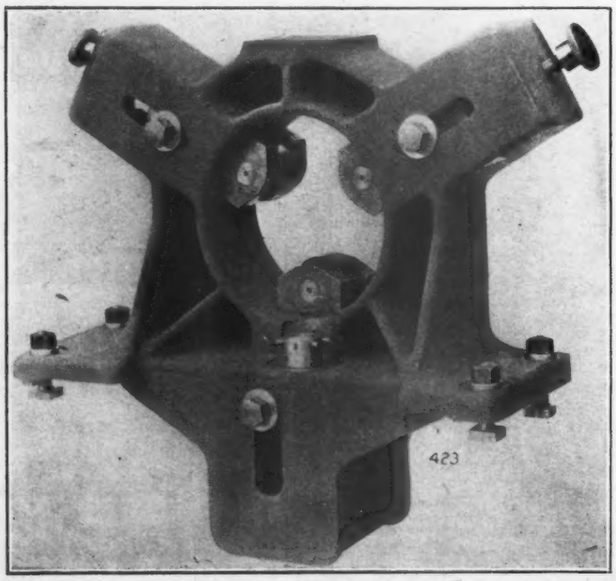
the table. Admitting air to the opposite end of the shaft causes the clutch J to engage with the wheel G, forcing the latter against the stationary clutch L, which is keyed to the shaft so that the wheel G drives the shaft through both of the clutches, one on either side in the proper direction for cutting at a speed which may be varied by changing the gears E and D. These are mounted on split bushings with conical holes, which permit the gears to be shifted with little trouble. In the operation of the planer the table stops move an air valve, which admits compressed air alternately to the opposite ends of the cylinder, and by regulating the velocity of the admission the speed of the reverse can be nicely gauged. It is arranged so that the table is brought to rest promptly and started up in the opposite direction without shock. There is no reversal of high speed pulleys, and the flywheel action of the parts whose motion is reversed, owing to their relatively small size, is unimportant. Fig. 3 shows a casting which was first planed on one edge with a heavy roughing cut, the tool being held in one of the side heads. A square nose finishing tool was then substituted and the stroke shortened, so that the cut terminated within the surface of the casting. The stopping point of the successive finishing cuts occurred in a practically true vertical line, and illustrates the uniformity of the reverse.

A separate belt is used to actuate the lifting gear and drive the feed motion. The latter is accomplished through a positive motion clutch, which is stopped and started at each reverse of the table. The side heads are lifted by the same screws which carry the cross rail. These screws are stationary under ordinary circumstances, and the heads are raised and lowered by rotating nuts.

The cross rail is secured to the uprights in such a way that the full strength of the housings is brought into play to resist the torsion of the cross rail, and at the same time the cross rail stiffens the housing against the twisting action of the side heads. This allows unusually heavy cuts to be taken. In some 54-in. planers of this construction two cuts of 60,000 lbs. each were taken in steel without any perceptible spring of the cross rail, although it was scarcely larger than is usually provided for a planer of that width.

HIGH SPEED FOLLOWER REST.

In order to obtain the best results in rough turning bars even as large as 8 ins. in diameter with high speed steel, experience has demonstrated that a substantial support or follower rest is necessary. The Lodge & Shipley Machine Tool Company, after trying several different metals for the jaws of such a follower rest, only to have them cut out, have adopted rollers, as shown in the photograph. These rollers are of hardened steel, and are mounted upon hardened and ground steel shafts, upon which they are fixed by screws through the face of the rollers. Liberal oiling facilities are provided for the journals of the roller shafts. In order that the jaws cannot be forced down too tightly, a sensitive adjustment is provided by the knurled knobs.



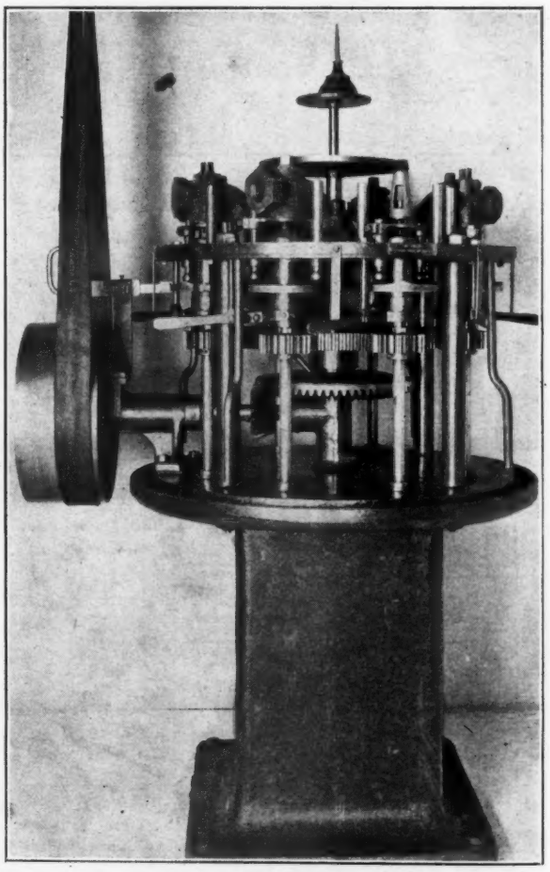
HIGH SPEED FOLLOWER REST—LODGE & SHIPLEY MACHINE TOOL COMPANY.

To insure still greater stiffness and rigidity the pad at the top may be planed, and by means of an angle bracket be connected to the wings of the carriage on the opposite side. It is claimed that double the output may be obtained on heavy bars on one of the company's high speed lathes with this device over that which may be obtained on the same lathe without a rest.

AUTOMATIC VALVE GRINDING MACHINE.

This machine was designed to facilitate the manufacture and repairs of the cut out and angle cocks used in connection with air brake apparatus but may easily be arranged to grind any plug valve or valves with disc seats such as are used in general practice. It is claimed that an eight spindle machine will grind from 200 to 400 old cocks or from 500 to 600 new ones in 10 hours and that very much better work is done by machine than by hand grinding.

The valve to be ground in is fastened to the end of one of



AUTOMATIC VALVE GRINDING MACHINE.

the spindles and the body of the valve is simply placed on the valve and is kept from revolving by the uprights or columns which are placed at either side of each spindle. No force other than the weight of the body is required to hold the two parts together while they are being ground. By means of the cam placed just above the spur gear on each spindle the body is lifted off the valve twice during each revolution of the spindle. Each spindle may be stopped or

started independently of the others by means of the jaw clutches.

An eight spindle machine, such as the one illustrated, weighs about 1,000 lbs. and occupies less than 4 sq. ft. of floor space. In addition to the eight spindle grinder the Automatic Valve Grinding Machine Company of Knoxville, Tenn., also make four and six spindle machines.

VAUCLAIN BALANCED COMPOUND LOCOMOTIVE.

FRISCO SYSTEM.

Information received since the publication of the description of the 4-cylinder Vauclain balanced compound locomotive of the Chicago & Eastern Illinois, on page 97 of the March number, indicates that instead of the weights given the actual weights are:

On trucks	45,800 lbs.
First pair of drivers	48,800 lbs.
Second pair of drivers	46,500 lbs.
Third pair of drivers	49,960 lbs.
On all drivers	145,260 lbs.
Total weight	191,060 lbs.

PERSONALS.

Mr. A. H. Gairns has been appointed master mechanic of the Colorado & Southern Railway at Cheyenne, Wyo.

Mr. J. J. Connor has been appointed general foreman of the Houston & Texas Central at Houston, Texas.

Mr. A. J. Poole has been transferred as master mechanic of the Seaboard Air Line, from Savannah to Atlanta, Ga.

Mr. H. M. Muchmore has been appointed master mechanic of the Paris & Great Northern, with headquarters at Paris, Tex.

Mr. C. E. Gossett has been appointed master mechanic of the Chicago, Rock Island & Pacific with headquarters at Eldon, Mo.

Mr. William Lincoln has been appointed master mechanic of the Northern Pacific at Staples, Minn., to succeed Mr. H. M. Curry, promoted.

Mr. George Holden has been appointed master mechanic of the Texas & New Orleans Railroad with headquarters at Beaumont, Texas.

Mr. W. P. Sproul has been appointed master mechanic of the Atlantic Coast Line at Savannah, Ga., to succeed Mr. F. S. Anthony, resigned.

Mr. Jacob Schilling has been appointed master mechanic of the Chicago, Peoria & St. Louis Railway, with headquarters at Peoria, Ill.

Mr. Thomas Nichols has been appointed machine shop foreman of the Baltimore & Ohio at Lorain, Ohio, to succeed Mr. W. F. Ryan.

Mr. F. Burke has been appointed travelling engineer and airbrake instructor of the Duluth, Missabe & Northern, with headquarters at Proctor, Minn.

Mr. S. T. Park has been appointed acting superintendent motive power of the Chicago & Eastern Illinois, with office at Danville, Ills. He has been master mechanic of that road.

S. Milliken has been appointed superintendent of motive power of the Houston & Texas Central, with headquarters at Houston, Texas, to succeed Mr. S. R. Tuggles, resigned.

L. L. Collier has resigned as master mechanic of the Newton & Northwestern to become general foreman of the Chicago Rock Island & Pacific shops at Dalhart, Texas.

Mr. J. E. Gould has been appointed master mechanic of the Chicago, Rock Island & Pacific at Goodland, Kan. He was formerly master mechanic of the Cincinnati, Hamilton & Dayton.

Mr. R. L. Langtim has resigned as mechanical engineer of the Denver & Rio Grande to become mechanical engineer of the Cincinnati, Hamilton & Dayton, with headquarters at Lima, Ohio.

Mr. H. M. Curry has been promoted from the position of division master mechanic of the Northern Pacific at Staples, Minn., to that of general master mechanic, with headquarters at St. Paul, succeeding Mr. A. W. Wheatley.

Mr. William Cockfield has been appointed locomotive superintendent of the Mexican Railway, with headquarters at Orizaba, Mexico, to succeed Mr. J. M. Muir, resigned. Mr. Cockfield was formerly locomotive superintendent of the Interoceanic Railway of Mexico.

Mr. George W. Smith has resigned as superintendent of motive power of the Chicago & Eastern Illinois to become superintendent of machinery of the Missouri Pacific Railway, with headquarters at St. Louis, succeeding Mr. J. W. Luttrell, resigned.

Edward Longstreth, who was for a number of years general superintendent of the Baldwin Locomotive Works, and a member of the firm of Burnham, Williams & Co., died in Philadelphia, February 24th, at the age of 64 years. He began as an apprentice in the Baldwin Works in 1857, and ten years later became general superintendent. After three years in this position he was admitted to the firm. He was one of the leaders in the development of these works, and contributed in a very important way to their success.

NEW CATALOGUES.

VALVE TROUBLES AND HOW TO AVOID THEM.—A small pamphlet from Jenkins Bros., 71 John street, New York City.

METAL SAWS.—Catalog No. 3 from the Higley Machine Company of New York, N. Y., describes the various metal saws and saw blade grinders made by them.

DRILL-GRINDERS.—Catalog C from the Washburn shops of the Worcester Polytechnic Institute of Worcester, Mass., describes the drill-grinders manufactured by them.

MILLING MACHINES.—A handsome catalogue has just been recieved from the Kempsmith Manufacturing Company, Milwaukee, Wis., which describes their line of milling machines and attachments.

COMMON SENSE AND MATHEMATICS.—In a small pamphlet, with this title, the Lucas Machine Tool Company, Cleveland, O., emphasize the advantages afforded by their "Precision" boring, drilling and milling machine.

BUDA METALS.—Bulletin No. 11 from the Buda Foundry and Manufacturing Company, Railway Exchange building, Chicago, describes their new anti-friction metals, bronzes and hardened or "steel" copper.

MOTORS.—Folder No. 4038 from the Westinghouse Electric & Manufacturing Company of Pittsburg, Pa., describes their type F induction motor and illustrates some typical applications. Folder 4039 describes their type R direct current motors.

ALTERNATING CURRENT GENERATORS.—Bulletin No. 50 from the Crocker-Wheeler Company, Ampere, N. J., describes in detail their belt type alternating current generators, which are made in sizes from 30 to 250 K. W. A.

TRUCKS.—A handsome catalog from the J. G. Brill Company of Philadelphia, Pa., describes in detail their 27 E truck, considers the advantages to be gained by its use, and presents a number of strong testimonials and a long list of its users.

VERTICAL MILLING MACHINES.—Catalog No. 40 from the Newton Machine Tool Works, Philadelphia, Pa., illustrates several designs of vertical milling machines, both belt and motor driven, which are specially adapted for locomotive and railroad shops.

TOOLS AND SUPPLIES FOR STEAM, WATER AND GAS USERS.—A pocket catalog from the Walworth Manufacturing Company, Boston, Mass., manufacturers of brass and iron goods and tools and dealers in wrought iron pipe and supplies for steam, water and gas work.

VARIABLE SPEED MOTOR DRIVES.—Bulletin No. 37A from the Northern Electrical Manufacturing Company, Madison, Wis., considers the best types of controllers to use with variable speed motor drives for different machine tools and illustrates several applications of Northern motors.

VARIABLE SPEED MOTORS.—Bulletins 5, 6 and 9, series B, from the Electro-Dynamic Company, Bayonne, N. J., furnish data and dimensions of the various sizes of their inter-pole variable speed motors, describes their construction in detail and considers the most important advantages afforded by this type of motor.

ELECTRIC MOTORS.—Circular No. 1097 from the Westinghouse Electric & Manufacturing Company, Pittsburgh, Pa., describes in detail their type K direct current, series wound motors for crane, hoisting, and similar service. Circular No. 1099 describes their bi-polar motors for direct current circuits, which are made in sizes from 1-6 to 1¾ h.p., and wound for 110 and 220 volts.

PROTECTION OF STEEL FROM CORROSION.—The April number of *Graphite* contains an impressive number of fine engravings of notable buildings and bridges in various parts of the world, all of which are protected by graphite paints. It also contains seasonable talks on good paint and good painting. Those who are responsible for steel structures should procure copies from the Joseph Dixon Crucible Company, Jersey City, N. J.

HOW TO HANDLE WATER FOR THE LOCOMOTIVE.—Bulletin No. 2 from the Otto Gas Engine Works, 360 Dearborn street, Chicago, considers the methods of supplying water to locomotive tenders and describes and nicely illustrates their stand pipe, new steel bottom tank and the various tank and water column fixtures made by them. With improved appliances water can be discharged into the tender tank at the rate of 6,000 gals. per minute.

PROGRESS REPORTER.—The April number just received from the Niles-Bement-Pond Company is devoted entirely to locomotive manufacture and contains 46 full-page half-tone illustrations showing their machines and cranes as installed at the Schenectady and the Brooks works of the American Locomotive Company. Every motive power officer should look this number over carefully, as most of the machines are adapted to locomotive repair shop work, and the methods of handling the work and the rate at which some of the parts are machined will afford the means of a valuable and instructive comparison with what is being done in their own shops.

NOTES.

CROCKER-WHEELER COMPANY.—Mr. B. A. Schroder has been transferred from the St. Louis to the New Orleans office, to succeed Mr. W. P. Field, who has gone to the Boston office.

MANNING, MAXWELL & MOORE.—Mr. E. B. Boye has been appointed manager of the Cleveland office of this firm in Williams Block, Cleveland, O. He has been connected with the Chicago office for the past five years.

STOCKBRIDGE MACHINE COMPANY.—This company announces that they have made arrangements with the Niles-Bement-Pond Company for the sole agency of their shapers in New York, Boston, Chicago and London.

THE BUDA FOUNDRY & MANUFACTURING COMPANY.—This company has been successful in procuring a large order for track supplies to be used in the Panama Canal work, and shipments are now being made.

AMERICAN ELECTRIC & CONTROLLER COMPANY.—Mr. Chas. D. Knight, who has been connected with the engineering departments of the General Electric Company, National Electric Company and the Cutler-Hammer Manufacturing Company, has been appointed chief engineer of this company, and under his supervision a complete line of alternating and direct current controllers, starters, automatic switches, solenoids, etc., will be manufactured in addition to the "Rheocrat." His office address is 12 Dey street, New York.

CROCKER-WHEELER COMPANY.—The Trustees of the Sanitary District of Chicago have placed an order with this company for four 4,000-k.w. 3-phase 60-cycle 6,600-volt alternating current generators with exciters.

THE W. L. MILLER COMPANY.—This company has been organized to manufacture and contract for complete power plants, automatic locomotive boiler washing equipment, for washing and filling locomotive boilers with water heated by waste heat; for vacuum heating systems for roundhouses, shops and terminal buildings and for boilers, engines, pumps, heaters and piping. Mr. W. L. Miller, the president, was formerly connected with the Erie Heating Company, but has severed this connection to form the company which bears his name. The offices are Clark and Monroe streets, Fort Dearborn Building, Chicago.

NEW WATSON-STILLMAN PLANT.—The Watson-Stillman Company have moved into their new works at Aldene, N. J., where excellent shipping facilities are available on the Lehigh Valley Railroad. The plant includes a 100 by 182 ft. machine shop, of two stories, and a 120 by 35 ft. annex, a 62 by 100 ft. store house, a 60 by 74 ft. pattern shop, a 50 by 30 ft. blacksmith shop and powerhouse with electric distribution. This plant adds greatly to the manufacturing facilities of the company, all of the equipment being of the best, and it also provides admirably for manufacturing and finished stores.

J. G. BRILL COMPANY.—This company has lately received the following orders for its patented "Eureka" maximum traction trucks: 180 for the Tokio Electric Railway Company, Japan; 90 for the New South Wales Government tramways, Australia; 40 for the Tokio-Densha tramways, Japan; 42 for Marseilles, France, and 40 for Wigan, England. The "Eureka" truck was planned to meet all the difficult conditions found in cities, and is to-day more largely used than any other truck. The advantages claimed are that it carries long cars as low as does a single truck, and by bringing the load at certain points upon the side frames near the large yokes has the traction necessary to start quickly and climb heavy grades easily. The truck is standard in New York, Brooklyn, Baltimore, Boston, London, Liverpool, Paris, Sydney, Tokio and other large cities.

FEDERAL COURT SUSTAINS TESLA PATENTS.—In pursuance of a decision handed down by him on February 20th, in the United States Circuit Court for the eastern district of Wisconsin, sustaining the contention of the Westinghouse Electric & Manufacturing Company that the synchronous motors of the National Electric Company were an infringement of the broad rights covered in Tesla patents Nos. 381968, 381969, 382280, 382281, Judge Seaman, in Milwaukee, on February 24th, enjoined the National Electric Company from the further sale of such motors. The decision in the suit is the first that has been obtained in the litigation begun some time ago by the Westinghouse Company to prevent the sale of synchronous motors and rotary converters by American manufacturers not enjoying a license under the Tesla polyphase motor patents. A decision is now pending in the United States Circuit Court for the southern district of Ohio in the suit brought by the Westinghouse Company against the Bullock Electric Manufacturing Company, alleging a similar infringement of the same patent rights in the sale of Bullock synchronous motors and rotary converters. The final hearing in the latter suit was conducted before Judge Thompson, in Cincinnati, on February 7th and 8th, Mr. Frederic H. Betts and Mr. Page appearing for the complainant. The Tesla patents involved in these suits have been the subject of considerable litigation in the past few years. The action instituted by the Westinghouse Company a number of years ago against the Thomson-Houston Company, for alleged infringement of the Tesla patents, was discontinued upon the execution of a patent agreement, under which the General Electric Company has for several years manufactured and sold induction and synchronous motors and rotary converters. A number of manufacturers have been enjoined from manufacturing induction motors, but the decision in the suit against the National Electric Company is the first court ruling that the synchronous motor is within the generic Tesla invention.

WANTED—Position as roundhouse foreman by man of executive ability and knowledge through experience. Has held such a position and present position of shop foreman for six years. Address M., care of Editor, AMERICAN ENGINEER AND RAILROAD JOURNAL, 140 Nassau St., New York.

A TABULAR COMPARISON OF NOTABLE EXAMPLES

ARRANGED WITH RESPECT TO CLASSES AND WEIGH

PASSENGER LOCOMOTIVES.

Type—Drivers / Type—Name	4—6—2 (PACIFIC).								2—6—2 (PRAIRIE).						
Name of railroad	C. & A.	C. & A.	M. C. R. R.	N. P.	A. T. & S. F.	N. Y. C. & H. R.	C. M. & St. P.	C., R. I. & P.	L. S. & M. S.	C., B. & Q.	A. T. & S. F.	C., B. & Q.	L.S.&M.S.	S. P. Ry.	N.
Road No. or class	602	601	L	Q—1	1,200	K	F2-851	801	J—41	1950	P-14-A	1918	J-40	3022	
Builder	Baldwin	Baldwin	American	American	Baldwin	American	C. M. & St. P.	American	American	American	Baldwin Vauc. Comp.	Baldwin	Brooks	Baldwin Vauc. Comp.	Am Col
Simple or compound	Simple	Simple	Simple	Simple	Simple	Simple	Simple	Simple	Simple	Simple		Simple	Simple		
When built	1904	1903	1904	1904	1903	1904	1905	1903	1904	1905	1901	1904	1900-1	1903	
Tractive power	29,900	28,800	28,500	31,000	33,500	28,500	32,500	28,300	27,800	35,050	27,500	35,050	24,700	21,700	2
Weight, total lbs	221,500	221,300	221,000	219,000	216,100	215,000	208,750	193,000	233,000	212,500	210,800	208,550	174,500	200,030	20
Weight on drivers	135,510	145,000	140,500	142,500	147,400	141,000	130,500	132,300	165,200	154,000	143,600	151,070	130,000	102,190	11
Weight on leading truck	40,500	36,300	42,500	39,000	30,000	36,000	44,250	32,300	26,000	.....	29,700	23,260	21,500	61,620	5
Weight on trailing truck	45,490	40,000	38,000	37,500	38,700	38,000	34,000	28,400	41,800	.....	37,500	34,220	23,000	36,220	4
Weight of tender loaded	166,600	166,600	122,600	128,800	138,800	127,000	125,600	141,500	155,710	.....	112,600	152,000	124,500	144,850	12
Wheel base, driving, ft. and ins.	13-4	13-9	13-0	12-0	13-8	13-0	12-6	12-4	14-0	13-4½	13-8	13-4½	14-0	6-10	
Wheel base, engine, ft. and ins.	33-4	32-8	33-7½	32-6	33-9½	33-7½	32-5	31-10	34-3	30-8½	32-2	30-8½	31-9	31-3½	
Wheel base, engine and tender	62-5½	62-0	60-5	62-0½	62-10½	59-0	59-11½	58-9	62-3½	62-2¾	57-8¾	55-8½	57-2¼	65-2¾	
Driving wheels, diameter, ins.	77	80	75	69	79	75	72	69	79	69	79	69	81	79	
Cylinders, diameter, ins.	22	22	22	22	22½	22	23	21	21½	22	17 & 28	22	20½	15 & 25	15½
Cylinders, stroke, ins.	28	28	26	26	28	26	26	26	28	28	28	28	28	28	
Heating surface, firebox, sq. ft.	179	202	180.3	179.4	192.8	178.65	245.6	164		170.9	195	190		154	1
Heating surface, arch tubes	.....	.....	23.6	9	.....	27.35	.....	.....	222	.....	.....	51	190	.....	
Heating surface, tubes	2,874	3,234	3,690.6	3,361	3,402	3,570	3,136	2,958	3,679	3,343	3,543	3,354	3,172	2,884	3
Heating surface, total	3,053	3,436	3,894.5	3,549.4	3,595	3,776	3,381.6	3,122	3,901	3,513.9	3,738	3,575	3,362	3,038	3
Firebox, length, ins	108	108	96⅛	96	108	96⅛	125⅛	84	108⅛	109	108	108⅛	84⅛	119¾	9
Firebox, width, ins	66	72	75¼	65¼	71¼	75¼	41⅛	74	73¼	73	71¼	72¼	83¼	63⅜	7
Grate area, sq. ft	49.5	54	50.23	43.5	53.5	50.23	35.84	43.2	55	54	53.5	55	48.6	.....	5
Boiler, smallest diameter, ins.	70	70	72 1-16	70⅝	70	70⅝	72	66⅛	70	70	70	70	66	66	7
Boiler, height center, ins.	113	113	113	115	112	113	113	113½	114	.....	112	107¾	110	117½	11
Tubes, No. and diameter in ins.	245-2¼	276-2¼	354-2	374-2	290-2¼	303-2¼	363-2	304-2	322-2¼	301-2¼	318-2¼	301-2¼	285-2¼	346-2	3
Tubes, length, ft. and ins.	20-0	20-0	20-0	18-6	20-0	20-0	16-6	18-7	19-6	19-0	19-0	19-0	19-0	16-0	1
Steam pressure, lbs	200	200	200	200	220	200	200	200	200	210	200	210	200	200	2
Type of boiler	Straight	Straight	Straight	E. W. T.	W. T.	Straight	.....	W. T.	E. W. T.	Straight	Straight	Straight	W. T.	W. T.	St
Fuel	Bit. Coal	Bit. coal	Bit. Coal	Bit. coal	Bit. coal	Bit. Coal	Bit. coal	Bit. coal	Bit. coal	Bit. coal	Bit. coal	Bit. coal	Bit. coal	Oil	Bit
Reference in American Engineer and Railroad Journal	1904, p. 133	1903, p. 85	1904, p. 347	1905, p. 8	1903, p. 443	1904, p. 87	1905, p. 74	1903, p. 351	1904, p. 413	1905, p. 78	1901, p. 373	1904, p. 356	1901, p. 69	1903, p. 329	19

FREIGHT LOCOMOTIVES.

Type—Drivers / Type—Name	0-6-6-0 Mallet	0-10-0 Geared	2-10-2 Santa Fe	2—10—0 (DECAPOD).			2—8—2 (MIKADO).		2—8—0 CONSOLID						
Name of railroad	B. & O.	C. R. I. & P.	A.T. & S.F.	A.T. & S.F	A.T. & S.F	M., St. P. & S. S. M.	N. P.	A.T. & S.F.	B. & L.E.	Union.	L.S.&M.S.	Lehigh Valley	N.Y. C. & H. R.	L.S.&M.S.	N. Y H
Road No. or class	.....	165	900	940	989	600	W (com.)	900	150	95	G-46	1301-15	G-4	G-5	
Builder	American	Lima	Baldwin	Baldwin	American	Baldwin	American	Baldwin	Pittsburg	Pittsburg	American	Baldwin	American	American	Ame
Simple or compound	Mallet Comp.	Simple	Tandem Comp.	Tandem Comp.	Tandem Comp.	Vauc. Comp.	Tandem Comp.	Vauc. Comp.	Simple	Simple	Simple	Vauc. Comp.	Tandem Comp.	Simple	Sim
When built	1904	1902	1903	1902	1902	1900	1904	1902	1900	1898	1903-4	1898-9	1903	1904	1
Tractive power	70,000	47,000	62,800	62,500	55,300	48,600	45,000	55,600	63,800	53,300	46,500	47,700	46,600	45,700	45
Weight, total lbs	334,500	291,000	287,240	267,800	259,800	210,000	271,000	261,720	250,300	230,000	230,000	228,082	225,000	220,400	220
Weight on drivers	334,500	291,000	234,580	237,800	232,000	185,100	207,000	199,670	225,200	208,000	203,000	205,232	200,000	196,000	200
Weight on leading truck	.....	.....	23,420	30,000	27,800	24,900	30,300	27,250	25,100	22,000	27,000	22,850	25,000	24,400	20
Weight on trailing truck	.....	.....	29,240	.....	.....	.....	33,700	34,800	.....	.....	.....	.....	.....	.....	..
Weight of tender loaded	143,000	62,500 (empty)	158,500	.....	134,900	124,550	146,500	162,000	141,000	104,000	148,000	148,000	137,500	137,500	137
Wheel base, driving, ft. and ins.	30-8	44-5	19-9	20-4	20-0	19-4	16-6	16-0	15-7	15-7	17-3	15-0	15-0	17-0	17
Wheel base, engine, ft. and ins.	30-8	44-5	35-11	29-10	28-11	28-0	34-9	31-6½	24-4	24-0	26-5	23-10	23-7	25-11	25
Wheel base, engine and tender	64-7	54-4	66-0	59-6	62-0	58-3	63-1	62-0	57-11¾	54-9½	58-0	57-10¼	59-1	60-7	60
Driving wheels, diameter, ins.	56	40	57	57	57	55	63	57	54	54	58	55½	51	63	
Cylinders, diameter, ins.	20 & 32	15	19 & 32	19 & 32	17½ & 30	17 & 28	19 & 30	18 & 30	24	23	23	18 & 30	16 & 30	23	
Cylinders, stroke, ins.	32	17	32	32	32	32	30	32	32	32	30	30	30	32	
Heating surface, firebox, sq. ft.	219	156	210	210.3	205.4	201	200	210.3	241	205		193	201		189
Heating surface, arch tubes	.....	.....	.....	23.9	.....	.....	9	.....	.....	.....	232	.....	26	220	30
Heating surface, tubes	5,366	1,837	4,586	5,155.8	4,476.5	2,799	3,819	5,155.8	3,564	3,321.5	3,725	3,952	3,915	3,717	3,7
Heating surface, total	5,585	1,993	4,796	5,390	4,681.9	3,000	4,028	5,366.1	3,805	3,321.5	3,957	4,145	4,142	3,937	3,3
Firebox, length, ins.	108	96	108	108	108 1-16	132	96	108	132	120	108	120	105⅛	105 1-16	105
Firebox, width, ins.	96	54	78	78	79¼	41	65¼	78	40¼	40½	73¼	108	79⅜	75¼	75
Grate area, sq. ft.	72	36	58.5	58.5	59.5	37.5	43.5	58.5	36.8	33.5	55	90	58	54.9	54
Boiler, smallest diameter, ins.	84	60	78¾	78¾	78¾	68	74¼	78¾	84	80	80	80	77	81⅝	
Boiler, height center, ins.	120	.....	118	.....	.....	107	118	118	119¾	111⅜	119	103⅜	111	114	1
Tubes, No. and diameter in ins.	436-2¼	270-2	391-2¼	463-2¼	413-2¼	344-2	374-2	463-2¼	406-2¼	355-2¼	461-2	502-2	507-2	458-2	45
Tubes, length, ft. and ins.	21-0	13-0	20-0	19-0	18-6	15-7	19-6	19-0	15-0	15-0	15-6½	15-0⅞	14-9	15-6	1
Steam pressure, lbs	235	190	225	225	225	215	200	225	220	200	200	200	E. W. T.	200	2
Type of boiler	Straight	W. T.	W. T.	W. T.	E. W. T.	E.W. T.	E. W. T.	W. T.	Straight	Straight	W. T.	Wootten	Bit. coal	Straight	Stra
Fuel	Bit. coal	Bit. coal.	Bit. coal	Bit. coal	Oil	Bit. coal	Bit. coal	Bit. coal	Bit. coal	Bit. coal	Bit. coal	Ant. coal	1903, p.	Bit. coal	Bit
Reference in American Engineer and Railroad Journal	1904, pp. 237 & 262	1902, p. 244	1903, pp. 372 & 398, 1904, p. 176	1902, p. 192	1902, p.38	1900, p. 319	1905, p. 5	1903, pp. 16 & 109	1900, p. 214	1898, p. 365	1903, pp. 416 439 1904, p. 12	1898, p. 395	174	1905, p. 46	19

NOTE—These figures have been verified by the railroad officials in charge.

...R COMPARISON OF NOTABLE EXAMPLES OF REC...

ARRANGED WITH RESPECT TO CLASSES AND WEIGHTS.

PASSENGER LOCOMOTIVES.

...IFIC).				2—6—2 (PRAIRIE).					4—4—2			
...T. & F.	N. Y. C. & H. R.	C. M. & St. P.	C., R. I. & P.	L. S. & M. S.	C., B. & Q.	A. T. & S. F.	C., B. & Q.	L.S.&M.S.	S. P. Ry.	N. Y. C. & H. R.	A.T.&S.F.	C.,
...200	K	F2-851	801	J—41		P-14-A		J-40	3022	I-1	256	
...ldwin	American	C. M. &	American	American	1950	Baldwin	1918	Brooks	Baldwin	American	Baldwin	B
...mple	Simple	St. P.	Simple	Simple	American	Vauc.	Baldwin	Simple	Vauc.	Cole Bal.	Vauc.	4-c
		Simple			Simple	Comp.	Simple		Comp.	Comp.	Comp.	Co
...1903	1904	1905	1903	1904	1905	1901	1904	1900-1	1903	1904	1903	
...33,500	28,500	32,500	28,300	27,800	35,050	27,500	35,050	24,700	21,700	24,000	24,000	2
...16,100	215,000	208,750	193,000	233,000	212,500	210,800	208,550	174,500	200,030	200,000	193,760	19
...47,400	141,000	130,500	132,300	165,200	154,000	143,600	151,070	130,000	102,190	110,000	101,420	10
...30,000	36,000	44,250	32,300	26,000	.....	29,700	23,260	21,500	61,620	50,000	46,920	5
...38,700	38,000	34,000	28,400	41,800	.....	37,500	34,220	23,000	36,220	40,000	45,420	4
...38,800	127,000	125,600	141,500	155,710	.....	112,600	152,000	124,500	144,850	124,000	140,000	.
...3-8	13-0	12-6	12-4	14-0	13-4½	13-8	13-4½	14-0	6-10	7-0	6-4	
...9½	33-7½	32-5	31-10	34-3	30-8½	32-2	30-8½	31-9	31-3½	27-9	29-6	
...10½	59-0	59-11½	58-9	62-3½	62-2¾	57-8¾	55-8½	57-2¼	65-2¾	53-8	58-3½	.
...79	75	72	69	79	69	79	69	81	79	79	73	
...2½	22	23	21	21½	22	17 & 28	22	20½	15 & 25	15½ & 26	15 & 25	1
...28	26	26	26	28	28	28	28	28	28	26	26	
...92.8	178.65	245.6	164	} 222 {	170.9	195	190	} 190 {	154	175	190	
.....	27.35	.....	.....		.....	.....	51		.....	23	.....	
...3,402	3,570	3,136	2,958	3,679	3,343	3,543	3,354	3,172	2,884	3,248	2,893	3,
...3,595	3,776	3,381.6	3,122	3,901	3,513.9	3,738	3,575	3,362	3,038	3,446	3,083	3
...108	96⅛	125⅛	84	108⅛	109	108	108⅛	84⅛	119¾	96⅛	107 15-16	
...1¼	75¼	41⅛	74	73¼	73	71¼	72¼	83¼	63⅜	75¼	66	
...53.5	50.23	35.84	43.2	55	54	53.5	55	48.6	.....	50.23	49-4	
...70	70⅝	72	66⅛	70	70	70	70	66	66	70⅝	66	
...12	113	113	113½	114	.....	112	107⅜	110	117½	111 1-16	105	.
...-2¼	303-2¼	363-2	304-2	322-2¼	301-2¼	318-2¼	301-2¼	285-2¼	346-2	390-2	273-2¼	27
...0-0	20-0	16-6	18-7	19-6	19-0	19-0	19-0	19-0	16-0	16-0	18-1	
...220	200	200	200	200	210	200	210	200	200	220	220	
...T. T.	Straight	.....	W. T.	E. W. T.	Straight	Straight	Straight	W. T.	W. T.	Straight	W. T.	
... coal	Bit. Coal	Bit. coal	Bit. coal	Bit. coal	Bit. coal	Bit. coal	Bit. coal	Bit. coal	Oil	Bit. coal	Bit. coal	B
...8, p.	1904, p.	1905, p. 74	1903, p.	1904, p.	1905, p.	1901, p.	1904, p.	1901, p.	1903, p.	1904, p.	1903, pp.	19
...43	87		351	413	78	373	356	69	329	166	212 & 234	

FREIGHT LOCOMOTIVES.

...(DECAPOD).		2—8—2 (MIKADO).		2—8—0 CONSOLIDATION.								
... & S.F	M., St. P. & S. S. M.	N. P.	A.T. & S.F.	B. & L.E.	Union.	L.S.&M.S.	Lehigh Valley	N.Y. C. & H. R.	L.S.&M.S.	N. Y. C. & H. R.	A. T. & S. F.	
...989	600	W (com.)	900	150	95	G-46	1301-15	G-4	G-5	G-5		A
...erican	Baldwin	American	Baldwin	Pittsburg	Pittsburg	American	Baldwin	American	American	American	Baldwin	T
...ndem	Vauc.	Tandem	Vauc.	Simple	Simple	Simple	Vauc.	Tandem	Simple	Simple	Vauc.	
...mp.	Comp.	Comp.	Comp.				Comp.	Comp.			Comp.	
...902	1900	1904	1902	1900	1898	1903-4	1898-9	1903	1904	1903	1902	
...,300	48,600	45,000	55,600	63,800	53,300	46,500	47,700	46,600	45,700	45,700	45,300	
...,800	210,000	271,000	261,720	250,300	230,000	230,000	228,082	225,000	220,400	220,200	214,600	2
...,000	185,100	207,000	199,670	225,200	208,000	203,000	205,232	200,000	196,000	200,000	191,400	1
...,800	24,900	30,300	27,250	25,100	22,000	27,000	22,850	25,000	24,400	20,200	23,200	
.....	.....	33,700	34,800	.....	.....	.....	.....	.....	.....	.....	.....	
...,900	124,550	146,500	162,000	141,000	104,000	148,000	148,000	137,500	137,500	137,500	110,000	
...0-0	19-4	16-6	16-0	15-7	15-7	17-3	15-0	15-0	17-0	17-0	15-4	
...-11	28-0	34-9	31-6½	24-4	24-0	26-5	23-10	23-7	25-11	25-11	24-6	
...2-0	58-3	63-1	62-0	57-11¾	54-9½	58-0	57-10¼	59-1	60-7	60-7	54-2¾	
...57	55	63	57	54	54	58	55½	51	63	63	57	
...& 30	17 & 28	19 & 30	18 & 30	24	23	23	18 & 30	16 & 30	23	23	17 & 28	1
...32	32	30	32	32	32	30	30	30	32	32	32	
...05.4	201	200	210.3	241	205	} 232 {	193	201	} 220 {	189.77	165	
.....	.....	9	.....	.....	.....		.....	26		30.23	.....	
...476.5	2,799	3,819	5,155.8	3,564	3,116.5	3,725	3,952	3,915	3,717	3,717	4,031	
...81.9	3,000	4,028	5,366.1	3,805	3,321.5	3,957	4,145	4,142	3,937	3,937	4,266	
...8 1-16	132	96	108	132	120	108	120	105⅛	105 1-16	105 1-16	84	1
...9¼	41	65¼	78	40¼	40½	73¼	108	79⅜	75¼	75¼	3-28 dia.	
...9.5	37.5	43.5	58.5	36.8	33.5	55	90	58	54.9	54.89	.....	
...8¾	68	74¼	78¾	84	80	80	80	77	81⅝	80	74	
.....	107	118	118	119¾	111⅜	119	103⅜	111	114	114	110	
...-2¼	344-2	374-2	463-2¼	406-2¼	355-2¼	461-2	502-2	507-2	458-2	458-2	652-1¾	
...3-6	15-7	19-6	19-0	15-0	15-0	15-6½	15-0⅞	14-9	15-6	15-6	13-7	
...225	215	200	225	220	200	200	200	200	200	200	210	
...W. T.	E.W. T.	E. W. T.	W. T.	Straight	Straight	W. T.	Wootten	E. W. T.	Straight	Straight	E W. T.	
...il	Bit. coal	Bit. coal	Bit. coal	Bit. coal	Bit. coal	Bit. coal	Ant. coal	Bit. coal	Bit. coal	Bit. coal	Oil	
..., p.38	1900, p. 319	1905, p. 5	1903, pp. 16 & 109	1900, p. 214	1898, p. 365	1903, pp. 416 439 1904, p. 12	1898, p. 395	1903, p. 174	1905, p. 46	1904, p. 16	1902, p. 10	

RECENT LOCOMOTIVES.

4—4—2 (ATLANTIC).					4—6—0 (TEN-WHEEL).					2-6-0 Mogul
&S.F.	C., B. & Q.	C. & A.	P. R. R.	P. R. R.	Lehigh Val.	D. & H. Co.	L. S. & M. S.	B. & M.	N.Y., N.H. & H. R. R.	N. Y. C. & H. R.
56	2,700	553	E-2 A	2,512		502	F-52	346	G-4-b	E-11
dwin	Baldwin	Baldwin	American	Soc. Als.	Baldwin	American	Brooks	American	Baldwin	American
auc.	4-cyl. Bal.	Simple	Simple	De Glehn	Vauc.	Simple	Simple	Simple	4-cyl. Bal.	Simple
mp.	Compound			Comp.	Comp.				Compound	
03	1904	1903	1903	1904	1900	1903	1899	1904	1904	1902
000	21,400	23,800	23,800	19,530	28,000	27,100	23,500	24,600	21,900	23,600
760	192,000	183,820	182,000	162,000	194,758	175,000	172,500	171,000	160,600	266,000
420	100,000	103,690	115,500	84,870	141,348	131,500	135,000	130,000	123,100	128,000
920	50,000	40,130	35,500	.....	53,410	43,500	37,500	41,000	37,500	24,000
420	42,000	40,000	31,000	.....	.....	.....	.....	.....	.....	.....
000	.....	166,600	132,500	132,500	96,500	120,000	124,500	111,400	109,400	114,000
4	7-3	7-8	7-5	7-0½	13-0	15-0	16-6	15-10	13-6	15-0
9-6	30-2	27-0	30-9½	28-6 9-16	25-3½	26-4	27-4	26-10	27-5	23-0
3½	.....	56-3½	60-2 9-16	59-5	52-8⅝	53-7½	55-2¼	54-6⅞	56-8	49-3½
3	78	80	80	80 5-16	72½	72	81	72	72	63
25	15 & 25	20	20½	14 3-16 & 23⅝	17 & 28	21	20	20	15 & 25	20
26	26	28	26	25 3-16	26	26	28	26	26	24
90	166.4	191.2	166	.....	161.4	179.68	} 202½ {	159.6	168.5	162
...	.....	.....	.....	.....	.....	78.54		27.3	.....	.....
,893	3,050.5	3,056.0	2,474	.....	2,525	2,405.5	2,260	2,631.6	2,497.5	2,275
,083	3,216.9	3,247.2	2,640	2,577	2,686.4	2,663.72	2,862½	2,818.5	2,666	2,437
15-16	96⅛	108⅛	111	114	114	119⅞	120	102⅛	120⅜	93
66	66¼	72¼	72	40	89⅞	102	44	65¼	41½	97⅞
9-4	44.14	54.2	55.5	33.37	71.25	84.85	36.6	44	34.69	63.2
66	64	70	65⅝	59⅝	64	66¼	66	66⅝	60	69
05	.....	113	109	.....	110	113	110	.....	101	110 1-16
2¼	274-2¼	326-2¼	315-2	139-2 13/16	325-2	308-2	343-2	336-2	318-2	365-2
8-1	19-0	16-0	15-0	14-5 5-16	15-0	15	15-0⅛	15-0½	15-1	12-0
20	210	200	205	227½	200	200	200	200	200	200
V. T.	W. T.	Straight	Belpaire	Belpaire	.....	.....	E. W. T.	E. W. T.	W. T.	Straight
coal	Bit. coal	Bit. coal	Bit. coal	Bit. coal	Ant. coal.	Culm	Bit. coal	Bit. coal	Bit. coal	Ant. Coal.
3, pp.	1904, p.	1903, p.	1903, p.	1904, p.	1900, p.	1903, p.	1899, p.	1904, p.	1904, p.	1902, p.
& 234	212	458	131	203	312	285	343	380	466	115

					4—8—0 MASTODON.		4—6—0 TEN-WHEEL.		0-8-0 Switcher.	0-6-0 Switcher.
T. & F.	N. P.	N. Y. C. & H. R.	C. P. R.	L.S. & M.S.	I. C.	Gt. N.	C. P. R.	'Frisco.	C. & O.	P. R. R.
dwin	.....	.....	1,621	G-42 b	640	100	1,300	289	8	B-6
auc.	American	Schen	American	Brooks	Brooks	Brooks	American	Baldwin	American	P. R. R.
mp.	Tandem	2-cyl.	S-Heat	Simple	Simple	Simple	S-Heater	4-cyl.	Simple	Simple
	Comp.	Comp.	Simple				Comp.	Bal. Comp.		
902	1901	1901	1904	1900	1899	1898	1903	1905	1903	1904
,300	44,900	39,300	36,800	35,700	48,900	48,600	31,200	31,000	41,200	36,100
,600	209,500	192,000	186,525	174,000	221,450	212,750	192,020	191,060	171,175	170,000
,400	185,500	166,000	164,000	154,000	181,400	172,000	141,095	145,260	171,175	170,000
,200	24,000	26,000	22,525	20,000	40,050	40,750	50,925	45,800	.....	.....
....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
	(empty)									
,000	47,000	114,000	125,700	124,500	147,600	96,000	122,000	120,000	121,160	132,500
5-4	15-0	17-0	15-10	17-4	15-9	15-10	14-10	13-6	13-7½	11-6
24-6	23-8	25-11	24-4½	25-6	26-6	26-8	26-1	27-7	13-7½	11-6
2¾	52-4½	53-11	53-4¼	55-4¼	60-2½	53-11	54-6	55-8	45-8	48-3¼
57	55	63	57	63	57	55	62	62	51	56
& 28	15 & 28	23 & 35	21	21	23	21	22 & 35	15½ & 26	21	22
32	34	34	28	30	30	34	30	26	28	24
165	173	155.4	166	} 221.3 {	263	235	180	160.7	164	152.1
....	22.9	27.1	.....		.....	.....	.....	.....	.....	.....
031	3,450.4	3,298.1	2,493.7	2,653.0	3,237	3,096	2,312.6	2,933.7	2,573	2,343
266	3,646.3	3,480.6	2,659.7	2,874.3	3,500	3,331	2,492.6	3,094.4	2,737	2,495.1
84	100 1-16	96⅛	96⅝	120⅛	131	123	102⅛	101⅞	80	90
8 dia.	75¼	75⅝	65¼	40¼	41¼	39¾	70¼	66	70	66
....	52.3	50.3	43.8	33.5	37½	35	49.82	46.69	38.8	41.25
74	74¾	70⅝	70⅝	67	80⅞	78	70½	64	67	67¼
110	111¼	115	111½	112⅛	116	113	111½	109	112½	.....
2-1¾	442-2	396-2	{ 22-5 } 244-2	340-2	424-2	376-2¼	{ 248-2 } 22-5	278-2¼	351-2	325-2
13-7	15.0	16-0	14-2½	15-0⅛	14-8⅝	13-10⅝	14-7	18-0	14-0	13-10¼
210	210	210	200	200	210	210	200	225	200	205
W. T.	.....	.....	W. T.	W. T.	Belpaire	Belpaire	W. T.	W. T.	W. T.	Belpaire
Oil	Bit. coal	Bit. coal	Bit. coal	Bit.coal	Bit. coal	Bit. coal	Bit. coal	Bit. coal	Bit. coal	Bit. coal
02, p.	.....	1901, p. 83	1904, p.	1900, p. 37	1899, p.	1898, p. 1	1903, p.	1905, p. 97	1904, p.	1904, p.
10			454		315		317		184	384

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RECENT DEVELOPMENT OF THE FOUR-CYLINDER BALANCED LOCOMOTIVE.

WITH COMMENTS ON SUPERHEATING.

BY A. VON BORRIES.

EDITOR'S NOTE.—Professor von Borries, from his intimate association with the modern development of German locomotive practice and his own important part in it, is qualified by wide experience to offer suggestions of the greatest value in the present stage of American practice.

The recent development of the locomotive has moved in two directions: The introduction of the four-cylinder balanced compound locomotives and the use of superheated steam. Many of the ideas contained in the present types are not new, but have been published a long time ago in patents and papers, then forgotten again, because the development of railroad service did not yet need them, or because science and practice were not then able to use them profitably in regular practice.

The four-cylinder balanced compound locomotive, which had its first development in France, then in Germany and Austria, is now regarded very favorably in the United States of America, so that there may be now running some 100 engines of this class, which number will increase at the end of this year to some 200. The good results, in consumption and steady running, which these engines showed on the testing plant at the St. Louis Exhibition in 1904 seem to have greatly extended this favorable opinion in the United States.

In America there are now two types of these engines, which resemble their European predecessors in the general arrangement: The Vauclain type, built by the Baldwin Works, where all four cylinders are arranged in one line under the front end, and all four pistons work on the front driving axle, as in the author's system, now generally used in Germany and Austria, and the Cole type, introduced by the American Locomotive Company, where the inside pistons work on the first, the outside ones on the second driving axle, as in the De Glehn system, generally used in France. The Vauclain system is illustrated in the AMERICAN ENGINEER in December, 1904, page 466, the Cole in May, page 166, and the De Glehn in June, page 203. [The Vauclain arrangement is now built as mentioned above, and also divided, as are the De Glehn and Cole arrangements.—EDITOR.]

In the valve gear there is a difference, which is independent from the general arrangement of the engines. The Vauclain engines have one, the Cole engines two piston valves for both cylinders of each side, driven by one valve stem, and accordingly giving equal cut-off in the h.p. and l.p. cylinders. In this respect European constructors generally prefer to give the l.p. cylinders longer cut-offs than the h.p. ones, which requires independent motion of separate valves. In the De Glehn engines the cut-off in the h.p. and l.p. cylinders is kept fully independent from each other, so that four link motions are needed. In the author's valve gear a fixed proportion between the two cut-offs is attained with only two link motions of the Heusinger-Walschaert type by proper dimensions of the main levers.

The first advantage of the four-cylinder engines over those of two cylinders is the perfect balancing of the accelerating and retarding forces of the reciprocating parts by their opposite or opposed motion on each side, without balance weights in the wheels. Such balance weights are only put in for the equalization of the revolving parts, so that no centrifugal forces disturb the equal pressure of the wheels on the rails. This advantage applies to both systems of motion equally. By the self-balancing of the reciprocating parts the jerky motion (in longitudinal direction) is suppressed totally, if the h.p. and l.p. pistons have equal weights, otherwise it is reduced to a minimum. The turning motion around the center of gravity is reduced theoretically to about one-half, but experience shows that in practice it is negligible, being overcome by the different resistances against side motions on both ends of the engine.

With the balancing of the piston or steam forces in the running gear, there is a difference between the systems. In the De Glehn and Cole arrangements the outside pair of pistons work on the second driving axle just in the same manner as in an ordinary outside two-cylinder engine. Now, experience shows that the piston forces cause a wear of the brasses in the axle-boxes in longitudinal direction, so that the journals are drawn fore and aft in the boxes, causing the well-known blows, and this causes flat spots on the left side drivers, on a place which touches the rails, when the crank has passed its front center. This flat spot seems to be caused by a short sliding of the wheels in that position. It is always on the side of the following crank. English engines, which have generally the right crank following, show it on the right drivers. The whole matter has been thoroughly examined by Mr. Busse, chief mechanical engineer of the Danish State Railways.

Now, these blows and those caused by the flat spots are the usual reasons for taking the engines into the shops for fitting up the journal brasses and turning the tires, which must be done deep enough on all drivers to cut away the flat spot on that one wheel. The only way to delay as long as possible this objectionable wear is to fit the brasses as tight as possible nearly half around the journals, but the blows come again after a longer run. Now, when an engine goes in the shops, everything is overhauled and made ready for the next running, so that the cost of repairs depend to a great extent, not upon the miles run, but upon the number of repairs. The en-

gine which keeps running for the largest number of miles will, therefore, generally be the cheapest in maintenance, even if it is more complicated.

In the De Glehn and Cole systems the second driving axle is exposed to similar but smaller piston forces. Therefore, these engines may show the same special wear after a longer run. I have not had sufficient experience in this system, but I want to direct the attention of those who have such engines under control to this point. For the first driving wheels there is no fear in this respect, because two-cylinder inside engines show this wear, according to Mr. Busse's experience, in a very reduced degree.

In the Von Borries-Vauclain system, where all pistons work on the front driving axle, the piston forces on each side balance themselves to a great extent. The journals get no horizontal wear in their brasses, and the engines run free from blows and irregular wear of tires until they must go to the shops for general wear. Experience on the Hannover division of the Prussian State Railroads has shown that 25 two-cylinder 4—4—0 compounds, engaged in heavy express service, have run as an average some 41,000 miles from one turning of the drivers to the next, whereas 9 four-cylinder engines of the 4—4—0 and 4—4—2 types reached 67,000 miles as an average, some of them more than 90,000 miles. These figures prove the economy of these four-cylinder engines in maintenance. It would be very interesting if American railroads would fix similar figures for both types of engines, and try their running after averaging 40,000 to 60,000 miles.

Another advantage of the four-cylinder engines against the two-cylinder ones is the practically unlimited diameter of the cylinders, so that they may be dimensioned so as to do their heaviest work with economical expansion. Also the draft on the fire is more uniform from the four jets per revolution, instead of two, and by the reduced exhaust pressure of the steam caused by the greater expansion. For these reasons, the four-cylinder engines steam better at slow and medium speeds, that is, they take the inclines at higher speeds.

As to the valve gear, extensive trials have been made by German and French railways to find the best proportions of cut-off in the h.p. and l.p. cylinders, also on two-cylinder compounds. Of course, this proportion depends much upon the dimensions of the gear, especially the clearance space in the h.p. cylinders and the inside clearance of the h.p. valves. Generally, it has been found that a cut-off of 15 to 20 per cent. longer in the l.p. cylinders than in h.p., or a fixed cut-off of 60 to 70 per cent. in the l.p. gives the greatest economy in steam consumption. But it must be stated that nearly all the engines have too small ports in the l.p. cylinders, their section being only 1-14 or 1-16 of the piston area. This fault is also the real reason why compounds in so many cases would not do for high speeds. The Prussian 4—4—0 express engine introduced by the author in 1891 was one of the first with ports of sufficient section, and has done very good work at high speeds. With small ports the cut-off in the l.p. cylinder had to be enlarged with increasing speed, for the purpose of giving the steam larger passages. Recent experiments with four-cylinder engines, where the l.p. cylinders have ports of 1-10 to 1-8 of the piston area, show that the cut-off may be reduced.

The real reason why the l.p. cylinder should have a longer cut-off than the h.p. is to keep the intermediate pressure low enough to prevent too high compression in the h.p. cylinders, with reasonable clearance spaces and inside cuts in valves. Of course, it is possible to run an engine with a proportion of piston areas of 1 to 2.8 with equal cut-off of 30 per cent. in both cylinders, but then the h.p. cylinder must have a clearance of 22 per cent. and large inside clearance in the valve, so that the engine will work less economically when run with longer cut-offs. The degree of expansion at 30 per cent. is

$$\frac{0.3 + 0.22}{2.8} = \frac{1}{5.4}.$$

With a piston proportion of 1 to 2.5 a clearance of 12 per cent. in the h.p. cylinder is sufficient when the cut-off in the l.p. cylinder is 15 to 20 per cent. greater than in the h.p. one. The total degree of expansion at 0.3 is

$$\frac{0.3 + 0.12}{2.5} = \frac{1}{6.}$$

This engine will work more economically at longer cut-offs, because the intermediate pressure thus rises, and the compression fills up the h.p. clearance space better, correcting the shorter compression. Therefore, the differential cut-off enables the engine to work more economically with different tractive force. As in the four-cylinder engine itself, in comparison with the two-cylinder, economy stands against simplicity, but I believe the economy will prove preferable.

The well-known fault of the two-cylinder compounds, that the great degree of total expansion causes much condensation in the l.p. cylinders, is felt still more on the four-cylinder engines, because they work with still larger expansion. This condensation, of course, reduces the economy. Examinations of indicator cards seem to show that there is very small condensation in the h.p. cylinders. Therefore, it would, perhaps, be a good plan to superheat the steam on its way from the h.p. to the l.p. cylinders, which might be done by a simple superheater in the smokebox. The difficulties of the high pressure and high-superheated steam would be avoided by this method. Of course, the l.p. cylinders would have to be larger in proportion to the larger volume of the superheated steam.

This leads me to the superheater engines, of which the first was built in Germany in 1898, according to plans prepared by Mr. W. Schmidt, of Wilhelmshohe. (This superheater was shown in the AMERICAN ENGINEER, November, 1902, page 340.) Mr. Schmidt's intention was to superheat the steam to such an extent that condensation in the cylinders would be avoided. For this purpose the steam of 176 lbs. pressure and 374 deg. of heat must be superheated to about 572 deg. Theoretically, superheating to this extent should give an economy of fuel of some 25 per cent., and of water of some 30 per cent., compared with simple engines for the same total work. As soon as the speed is higher than that which corresponds to the limit of adhesion, because of the increased capacity obtained per unit weight of the engine, superheating becomes still more effective. An ordinary express engine consumes one-half of its tractive force for its own motion; a superheater engine of same weight, which produces 30 per cent. more total tractive force, would draw a train of 60 per cent. heavier weight at the same speed.

These favorable figures seem to be not quite fulfilled now. But it has been stated that a superheater engine of the 4—4—0 type weighing some 54 tons does the same work in express service which requires a 4—4—2 compound of 62 tons. The work done by the superheater engines or, properly said, by the superheated steam, is excellent, the gain increasing with the speed. The small consumption of water is specially favorable for long runs. On the other hand, the superheater engines are still more liable to defects, and they are, therefore, oftener and altogether longer in the shops than other engines. This is caused partially by the heavier wear of driving boxes and tires, partially by occasional defects of the special parts connected with the superheating.

The simplest type of locomotive superheater is the Pielock, in which the central portion of the boiler flues is inclosed by a case, and thereby separated from the boiler, the water being kept out by the case. The steam from the throttle passes through this case and among the tubes on its way to the cylinders. This superheater is regarded favorably here in Germany, because of its simplicity, and because it gives no trouble in service. In some cases the tubes have become corroded outside, but this is the only point requiring attention. In all other respects boilers fitted with these superheaters are worked like others. A special feature of the Pielock superheater is that it may be applied to old boilers.

The horizontal wear of the driving brasses and the resulting blows and irregular wear of tires, as previously described, is greater than on other simple engines, because the superheaters have larger pistons, on account of the larger volume of

the steam, and, therefore, the piston forces are greater. Compared with compounds, the difference is still greater. I have no figures, like those mentioned before, when comparing the two and four-cylinder compounds, but it is important to state in practice the wear of tires for 100,000 miles running with the different types of engines. Of course, this figure and the smooth running would be nearly as good as with the four-cylinder balanced compounds, if the superheater engine is also built with four cylinders in the same manner. But then the question arises, whether it will not be better to retain the compound system with superheated steam. The question can only be settled by experience. On the Canadian Pacific Railroad the superheater compounds seem to have been more economical than similar simple engines, but the results seem not sufficient to settle the question. The four-cylinder simple engine would, of course, be simpler, but the compound would probably be more economical, owing to the larger degree of expansion and the larger opening of the ports by the valves.

Regarding the occasional defects, or "locomotive failures," what Mr. Basford reports from the English railways, that engine failures on trains are very unusual, also applies to German railways. Now, it is well known how successfully Mr. Schmidt and Mr. Garbe have overcome the great difficulties which stand against the use of steam of such high temperatures; but there are some features in this system which occasionally give trouble. What I have to say about this may, perhaps, be useful for our American colleagues, to enable them to avoid the same difficulties.

The large flue tube which conducts a part of the fire gases to the Schmidt smokebox superheater is liable to leak at its connection with the firebox tube plate, if this connection is not made with the greatest care. The flues of that superheater sometimes break near the tube plates of the steam boxes, in which they are fastened, probably by strain from expansion, by heat or vibration. Such a breakage makes the engine unfit to continue its run, because the tube ends cannot be filled up by plugs like a broken flue. The inside walls, which separate the superheater from the inner space of the smokebox are exposed to high heat and burnt or bent, even if made of cast steel, instead of sheet iron. For these reasons I prefer the newest style of superheaters of the Schmidt and the Cole types, where the superheater tubes are put into a number of enlarged flues in the upper part of the boiler. These flues will not be more liable to trouble than the others, because they are secured in the same manner, and the superheater tubes are free to expand and well supported. This style of superheaters also give the least weight. The Schmidt fire tube superheater, as applied to a Canadian Pacific locomotive, was illustrated in the AMERICAN ENGINEER in September, 1903, page 317, and the Cole superheater in September, 1904, page 338, and December of that year, page 456.

In the main steam tubes which conduct the steam to the cylinders all brass or copper parts must be avoided, because these materials do not stand the heat. Also I would prefer to conduct the side steam tubes immediately to the valve chests in the usual American manner through ports in the saddles, because the saddles would be heated locally too much, causing excessive inner strains, which might cause breakages. Also there would be a great loss of heat in the great mass of the saddle. For the same reasons the walls of the valve chest, where they are exposed to the superheated steam, should be insulated or independent from the other parts of the cylinder casting, especially from the cylinder walls themselves, where the heat would cause friction of the pistons. The steam pipes and valve chests must be large enough to act as a reservoir for the cylinders, together with the superheater.

The small piston valves employed by Mr. Schmidt of only 6 ins. diameter, with double ports for admission, are very light, durable and simple, but they have no packing rings, and a considerable part of the steam passes around them into the exhaust. It is difficult to fit them in the proper manner, so as to avoid friction on the one hand and excessive leakage on the other. Friction has in some cases caused breakage of valve stems. The first superheater engines had larger pistons with packing rings, which worked quite well and were tighter. Also in this question experience must show what sort of valve will be the preferable one.

Superheated steam is lighter than saturated, and, therefore, passes the ports and passages with less resistance. Therefore, the ports can be kept smaller in section, and the lead of the valves should be smaller than usual, especially with double-ported valves, to secure easy working of the engine. For large lead causes much friction, hot crank pins and loose cylinders. The economy of locomotives depends much upon the proper lead.

I hope that the foregoing remarks will be of some utility to our American colleagues in directing their attention to some points, which seem essential in the present development of the locomotive.

LOCOMOTIVE TESTS AT THE ST. LOUIS EXPOSITION.

THE CLASS H 6 A, 2—8—0 LOCOMOTIVE.

No. 1,499 of the Pennsylvania Railroad, tested at St. Louis last year on the testing plant, illustrated in this journal last month, was the first locomotive ever to undergo such a remarkably thorough series of tests. Bulletin No. 4, published by the Pennsylvania Railroad System, records this series of tests in full, and is a valuable document. It records seventeen tests made from June 11th to June 27th of last year. No test was shorter than 130 minutes, and the longest was 210 minutes. Until the complete record of the tests made on all the locomotives are available, as they will be later in book form, no comparisons can be drawn, and to properly represent the performances of the first locomotive the entire bulletin should be reproduced. An idea of the performance, however, may be given by stating the ranges of the data.

The lowest average boiler pressure was 176.9 lbs., while the highest was 203.4 lbs.; in general, the variation of average pressure did not exceed 5 per cent. The quality of steam, as measured by a throttling calorimeter, was uniformly high, the moisture never exceeding 1¼ per cent. The equivalent lbs. of water evaporated per sq. ft. of grate surface per hour ranged from 262 to 625. The equivalent evaporation per sq. ft. of heating surface ranged from 5.18 to 12.39 lbs. per hour. The maximum boiler horse power, based on 34.5 units, was 891.3; the horse power per sq. ft. of heating surface ranged from 0.15 to 0.359. The dry coal per sq. ft. of grate area per hour ranged from 22.7 to 86.4 lbs. The coal burned per sq. ft. of heating surface per hour ranged from 0.450 to 1.713 lbs. Firebox temperatures ranged from 1,427 to 2,112 deg. Fahr., and the smokebox temperatures from 561 to 726 deg. Fahr.

The equivalent evaporation per lb. of dry coal ranged from 11.53 to 6.63 lbs. The efficiency of the boiler dropped rapidly as the rate of evaporation increased, the range being between 78.93 per cent. and 45.37 per cent. In the smokebox gases the carbon dioxide ranged from 9.75 to 13.03 per cent. The lowest speed at which any test was run was 6.67 miles per hour, and the highest speed 26.68 miles. The highest indicated horse power was 1,036, obtained at 35 per cent. cutoff, at a speed of 120 r.p.m. The best performances of the engine was at 31 1-3 per cent. cutoff and 120.12 r.p.m. (about 20 miles per hour), and under which condition the steam consumption was 23.43 lbs. per indicated horse power per hour. The maximum average recorded drawbar pull was 2,278 lbs. at 80 r.p.m. and 37 per cent. cutoff. Higher drawbar pulls were not obtained because of the danger of stalling the brakes at low speeds and long cutoffs. A maximum dynamometer horse power of 848.6 was obtained at 120 r.p.m. and 35 per cent. cutoff. The general tendency was to increase the coal per dynamometer horse power as the speed increases, the minimum coal rate being 3.54 lbs. and the maximum rate 6.48 lbs. The lowest steam consumption was 26.14 lbs. per dynamometer horse power hour, obtained at 80 r.p.m. and 37 per

cent. cutoff. The average value of frictional horse power for speeds of 40, 80, 120 and 160 r.p.m. was 83.1, 132.5, 187.2 and 224.2, respectively. The machine efficiency ranged from 72.89 to 84.82 per cent. The maximum evaporative power of the boiler was between 25,000 and 26,000 lbs. of dry steam per hour, which is equivalent to a rate of evaporation of between 10 and 11 lbs. per sq. ft. of heating surface per hour.

The record of the tests is given in admirably complete form, by aid of tables and diagrams; the pamphlet also includes a detailed record of the data, drawings illustrating the engine, indicator cards and summaries of results. Those interested in the development of the American locomotive should procure copies of this record, as it is impossible to properly present the results in an abstract.

This locomotive was one of eight tested at the exposition, and the final results, affording an opportunity for comparisons, will be awaited with the greatest interest.

STEEL CAR DEVELOPMENT.

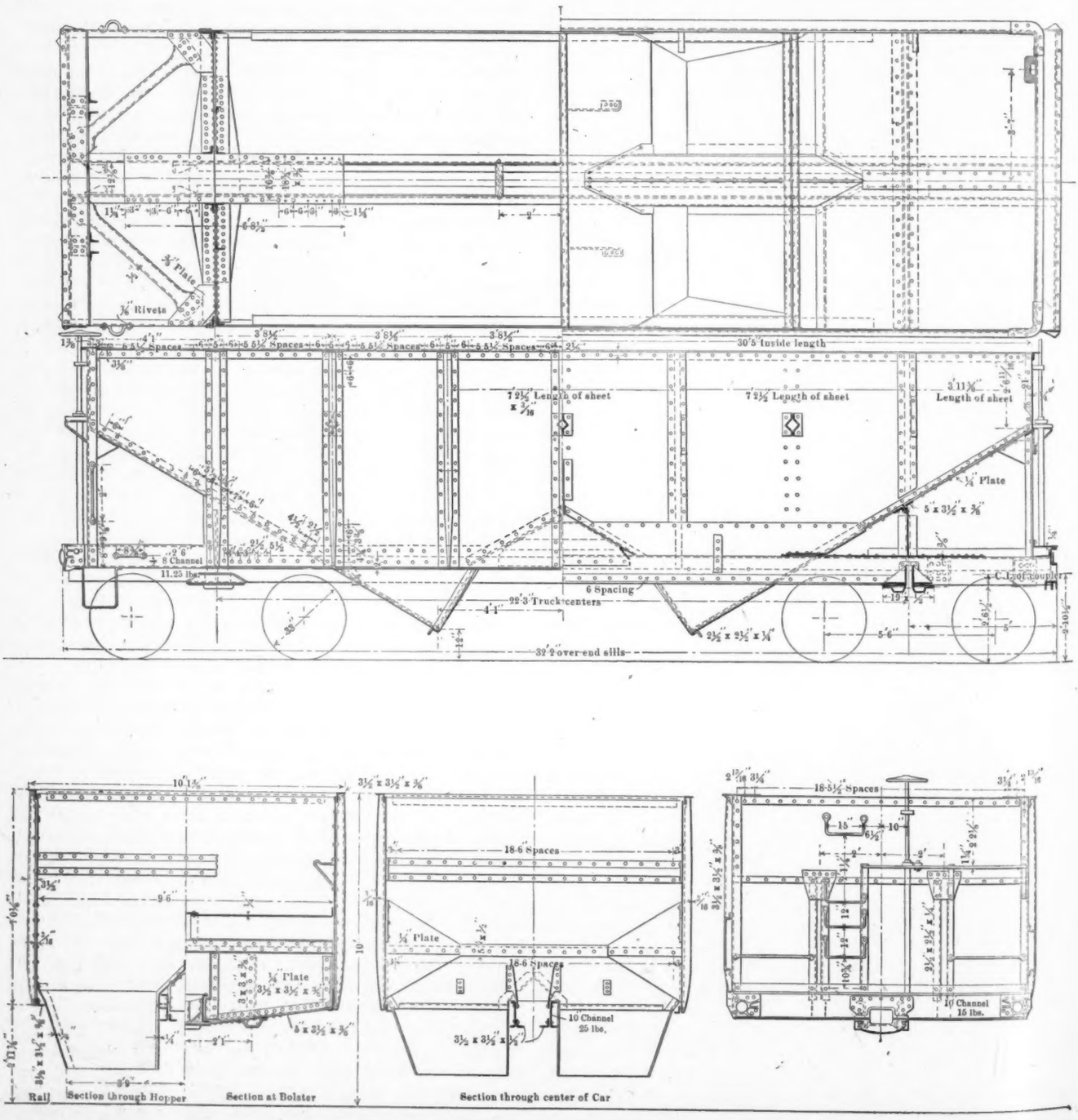
PENNSYLVANIA RAILROAD.

VI.

(*For previous article see June, 1904, page 209.*)

This series of descriptions of Pennsylvania Railroad steel cars has been interrupted, and will now be brought down to date. Previous articles will be found in the volume of 1903, pages 352, 402, 435, and in 1904, on pages 3 and 209.

The latest design is Class GLA, which is a development of the GL class, described on page 435 in December, 1903. The latter design has remained until recently the single standard coal car of this road. The type was brought out in pressed steel on the Bessemer & Lake Erie Railroad, and its adoption

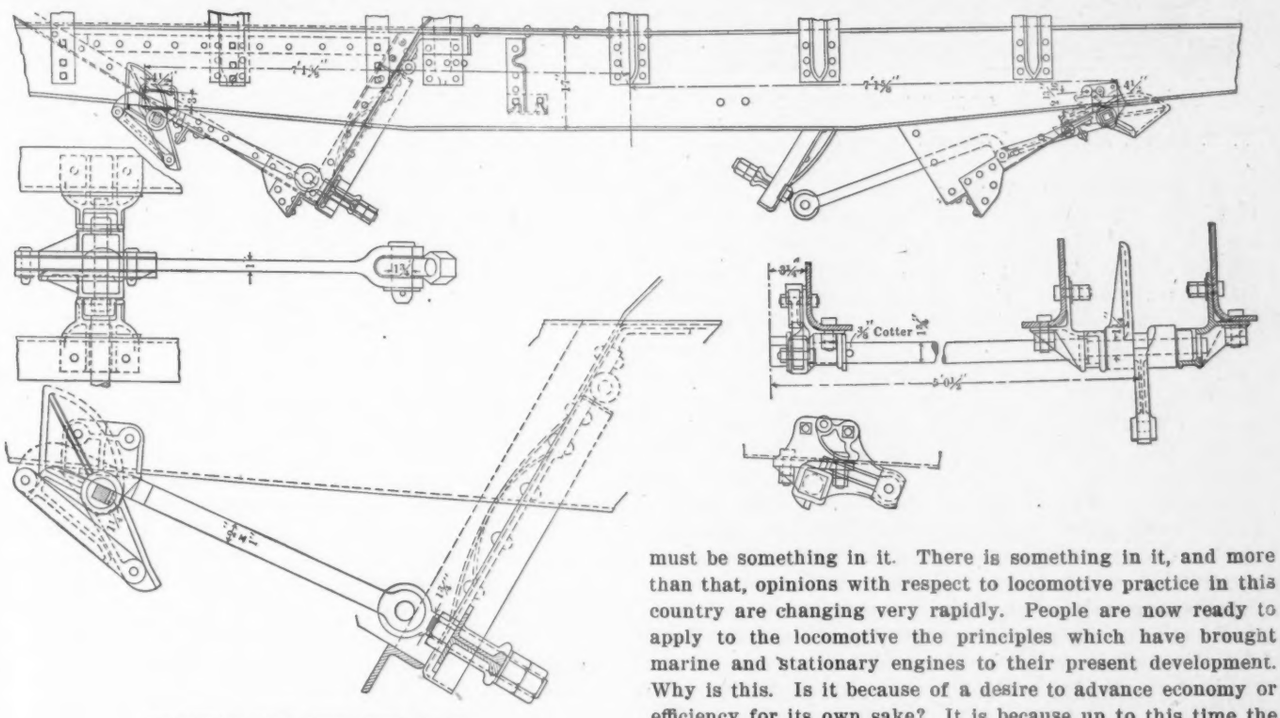


100,000 STEEL HOPPER CAR, CLASS GLA, PENNSYLVANIA RAILROAD.

by the Pennsylvania settled the form and type of the largest number of steel cars built in this country. The type resulted from the Class GG, wooden car. The design of the GL was simultaneous with the GM car, shown in November, 1903, page 402. The weight of the GL is 39,150 lbs.; the cubical capacity, 1,897 cu. ft., and its ratio of paying to dead load, 36.4 per cent. For the construction the description of this car may be consulted.

The GLA car is mainly a structural instead of a pressed steel car, and it has straight (instead of "fish-bellied") longitudinal sills, of 10-in. channels, reinforced at the lower flanges with 3½ by 3½ by ½-in. angles, as shown in the sectional views. It has no side sills between the bolsters, the short 8-in. channels reach only from the end sills to the bolsters. This is the first hopper coal car of 50 tons' capacity on this road, built in large numbers, utilizing the side plates in carrying the load. The GM hopper car (November, 1903, page 402), however, was constructed in this way, and established this principle in 1896.

The GLA design is similar to the GL in size and general features. It has the following dimensions:



SIMONTON DOOR OPERATING GEAR.

CLASS GLA HOPPER COAL CAR.

Total length over end sills	32 ft. 2 ins.
Length inside	30 ft. 5 ins.
Length between truck centers	22 ft. 3 ins.
Total height above rail	10 ft. 0 ins.
Total width	10 ft. 1⅜ ins.
Width inside	9 ft. 6 ins.
Weight	38,600 lbs.
Cubical capacity, level full	1,683.4 cu. ft.
Cubical capacity, heaped	1,900 cu. ft.
Ratio dead to paying load	35.1 per cent.

The weight is 550 lbs. less than that of its predecessor. For the first time on the Pennsylvania a single plate body bolster is employed in this type of car. It is secured to the inclined floor between two 5 by 3½ by ⅜-in. angles. To provide for end shocks the center sills have a cover plate 6 ft. 8½ ins. long, extending from the hood of the hopper to a point more than half-way from the bolsters to the end sills. The diagonal bracing of the ends of the frame is shown clearly in the plan view. In the center of the car diagonal plates stiffen the construction, as indicated in the side elevation. Instead of ¼-in. side plates on the preceding design, the GLA has plates only 3 16-in. thick, which still further lightens the construction.

These cars are equipped with the Simonton door operating gear, which is illustrated because it is an inexpensive gear, which has proved entirely satisfactory in service. A large number of these have been in use for several years without one having opened accidentally. This gear is operated by a squared shaft extending across the car. The door links terminate at their upper ends in the form of hooks. These hooks, when in the closed position, are drawn down over the shaft castings, locking the doors securely.

The GLA car is presented out of its order in this series, because it is the latest design of the Pennsylvania Railroad.

CAPACITY IN LOCOMOTIVES.

Seldom has a subject connected with locomotive practice been acorded the genial reception which is given quite generally to that of superheating. Thus far only two roads on this continent pretend to know superheating from experience, but everybody having to do with locomotives is ready to talk about it, and those who have no superheaters appear to know most about the principle. Was there ever before an improvement of the locomotive which impressed people as this has? There must be something in it. There is something in it, and more than that, opinions with respect to locomotive practice in this country are changing very rapidly. People are now ready to apply to the locomotive the principles which have brought marine and stationary engines to their present development. Why is this. Is it because of a desire to advance economy or efficiency for its own sake? It is because up to this time the locomotive has grown mainly by increasing size in order to increase capacity. Details of small engines which give no trouble are exceedingly troublesome when made bigger for the powerful engines of to-day. Weights have increased to the point of jeopardizing cool running even with the very best designs. Merely increasing size is unwise, unscientific and wrong. The time has come for making the most out of the weights which must be used and improvements, such as superheating, are accepted and gladly accepted because they offer means for increasing capacity.

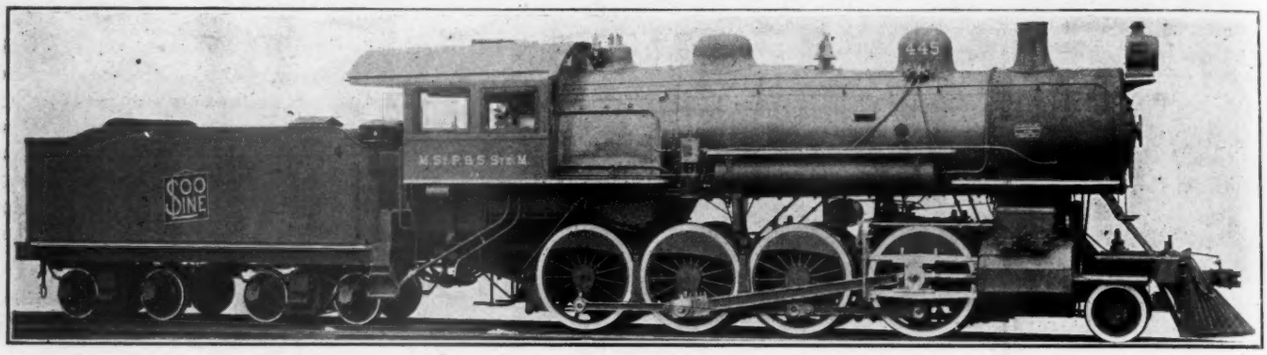
Compounding has never been appreciated by locomotive men until now, when it is clearly understood to be a source of increased capacity. Improved valve gears have had the "cold shoulder" for many years, but nowadays people are talking about them and they frequently ask which of several recently developed is the best and most likely to justify trial. Ten years ago a man with an automatic stoker would have been politely (perhaps) bowed out of the office. Now many are looking eagerly for the man who has a feasible plan to suggest for mechanical stoking.

All this has come rather suddenly. It all points in one direction—toward the greatest period of development of the locomotive and it justifies great hopes for the immediate future.

COMPOUND SUPERHEATER FREIGHT LOCOMOTIVE.

2—8—0 TYPE "SOO LINE" RAILWAY.

Two-cylinder compound locomotives of the 2—8—0 type having Cole superheaters have been put into service by the Minneapolis, St. Paul & Sault St. Marie Railway, which are generally similar to but are heavier and more powerful than others of the 2—8—0 type used on this road. The new ones have 37,300 lbs., as compared with 37,000 lbs. tractive effort



COMPOUND LOCOMOTIVE WITH SUPERHEATERS.—"SOO" LINE RAILWAY.

T. A. FOQUE, *Mechanical Superintendent.* AMERICAN LOCOMOTIVE COMPANY, *Builders.*

of the previous class. These engines were built at Schenectady. The Cole superheater provides 261.4 sq. ft. of heating surface, which is slightly less than 10 per cent. of the total heating surface. The superheater is provided for in 40 tubes 3½ ins. in diameter. While the arrangement of the superheater is that used previously by Mr. Cole, the superheater tubes have been changed somewhat from previous construction. The combination of two-cylinder compounding and superheating will be watched with interest, as it is an open question whether compounding is necessary with superheated steam. This road has a number of 2—8—0 type 2-cylinder compounds which are giving very satisfactory service, and the opportunity for comparison is an excellent one. The Canadian Pacific two-cylinder compound with superheater was illustrated in this journal in September, 1903, page 317, and the performance was recorded in December, 1904, page 457.

These locomotives were designed under the direction of Mr. T. A. Foque, mechanical superintendent of the road. The chief dimensions are given in the following table:

COMPOUND SUPERHEATER FREIGHT LOCOMOTIVE—"SOO LINE."

GENERAL DATA.

Gauge	4 ft. 8½ ins.
Service	Freight.
Fuel	Bituminous coal.
Tractive power	37,300 lbs.
Weight in working order	201,500 lbs.
Weight on drivers	172,000 lbs.
Weight on leading truck	29,500 lbs.
Weight of engine and tender in working order	318,400 lbs.
Wheel base, driving	17 ft.
Wheel base, total	25 ft. 11 ins.
Wheel base, engine and tender	55 ft. 10½ ins.

RATIOS.

Tractive weight ÷ tractive effort	4.61
Tractive effort x diam. drivers ÷ heating surface	916
Heating surface ÷ grate area	54.8
Total weight ÷ tractive effort	54.0

CYLINDERS.

Kind	Compound.
Diameter and stroke	23 and 35 by 34 ins.
Piston rod, diameter	4 ins.

VALVES.

Kind	Piston and slide.
Greatest travel	6 ins.
Outside lap	H.P., 1¼ ins.; L.P., 1 in.
Inside clearance	¼ in.
Lead in full gear	Line and line.

WHEELS.

Driving, diameter over tires	63 ins.
Driving, thickness of tires	3½ ins.
Driving journals, main, diameter and length	9½ by 12 ins.
Engine truck wheels, diameter	33 ins.
Engine truck, journals	6 by 10 ins.

BOILER.

Style	Extended wagon top.
Working pressure	210 lbs.
Outside diameter of first ring	67⅜ ins.
Firebox, length and width	98 by 70 ins.
Firebox plates, thickness	⅜ and ½ in.
Firebox, water space	5 and 4½ ins.
Tubes, number and outside diameter	224 2-in.; 40 3½-in.
Tubes, gauge and length	11 and 8, 15 ft. 9 ins. long.
Heating surface, tubes	2,407.5 sq. ft.
Heating surface, firebox	158 sq. ft.
Heating surface, total	2,565.5 sq. ft.
Superheater heating surface	266 sq. ft.
Grate area	46.8 sq. ft.
Exhaust pipe	Single.
Smokestack, diameter	16 and 18 ins.
Smokestack, height above rail	14 ft. 9 3-16 ins.
Centre of boiler above rail	115 ins.

TENDER.

Tank	U-shaped.
Frame	10-in. channels.
Wheels, diameter	33 ins.
Journals, diameter and length	5½ by 10 ins.
Water capacity	6,000 gals.
Coal capacity	10 tons.

IMPRESSIONS OF FOREIGN RAILROAD PRACTICE.

EDITORIAL CORRESPONDENCE.

BERLIN.

Continental locomotive designers have not hesitated to complicate their locomotives when any gain in economical operation was possible. They have used four cylinders and improved valve gears, and have many balanced locomotives. This is important to us, for we must follow in the use of four-cylinder balanced engines and in improved valve gears, but for reasons differing widely from those which inspired the French and Germans. Over here economy of operation is the main object, and balancing and lightening the parts seems less important. We need the four-cylinder balanced engines in order to increase wheel loads and to lighten the parts. We need the Walschaert valve gear because there is not room enough for eccentrics, because our eccentrics are so large as to involve excessive surface velocities, and because the Walschaert gear is lighter. It is interesting that we should be driven in the same directions for such different reasons. Incidentally, however, we shall also gain in the matter of operating economy, which is so much the better.

At this point a brief comparison between English, French and German locomotive practice seems appropriate. In England competition has had a very important effect, and the English railways serve the convenience of the people better than those of any other country which I visited. There are trains for all kinds of people; workmen travel to and from their homes to the large cities for almost nothing, and the best accommodations are available for those who can pay for them. English train service is exceedingly good, and the efficiency of the English railway "servant" is a source of

wonder. The amount of work done by a few poorly paid employees is remarkable. The competition has led to the perfection of locomotive design for conditions which are, however, rapidly changing as the weights of trains increase.

France went at the locomotive problem scientifically. With comparatively little competition, locomotive practice has been carefully and thoroughly developed, and the roads not having competition have profited by those which have it. The lines to the north and east, where competition exists, have the best equipment, and no locomotive practice better fitted to any given conditions is to be found anywhere.

Germany has settled down in general practice to a rather uniform lot of excellent locomotives, beautifully designed and built, but they do not make good when trains are late. Germany needs to provide heavy locomotives, with a greater amount of sustained capacity, as, like all other countries, her trains are becoming heavy.

Shop labor in Germany is cheap, and trained designers are everywhere available. This explains the beauty of finish of German engines and the care in design, which, for example, renders a main rod of the Von Borries' engines a work of art. The rods and parts of valve gear are very light, yet they do not break. I could not secure satisfactory figures of locomotive failures in Germany, but am confident that they are as infrequent in Germany as in England. Undoubtedly this is because the locomotives are not worked to death.

While I had a glimpse of Swiss and Italian practice, I did not make a study of the conditions of those two countries, and greatly regret that I could not go to Austria to study the work of Herr Golsdorf.

One's first railroad journey in Germany leaves an indelible impression of efficient station service. Instead of dallying at stations and working locomotives to the limit of their capacity to make up the time wasted, the Germans believe that the best way to make up time is when engines are standing still at stations. If the trains I used are fair samples, they surpass all others I ever rode in in this respect. The trains loaf along the road, but the station work is a fit subject for a cinematograph record. This comes from the station organization and from the military experience of every able-bodied German. When a train stops it passes out of the control of the conductor and locomotive engineer, and the station master becomes supreme. He has the baggage trucks "spotted" for the cars, and his men are all out and wideawake. There seems to be no lack of men, and they are thoroughly trained to work quickly. When everything is ready the station master blows a small brass horn, which would delight the heart of a five-year-old boy, but it starts the train and ends his responsibilities, which evidently have weighed upon him. Two minutes per stop was the time for many stations. This was not confined to long-distance trains. I found quick station service to be the rule in Germany, and it was pleasing as well as unexpected. Our general managers would do well to try the possibilities of this sort of thing at home. It would help the locomotives, the firemen, the coal pile, and, in fact, everything and everybody concerned in train service.

In Germany among many locomotive designers Professor A. von Borries is a central figure. He is professor of the Technical High School at Berlin, and is also state counsellor in locomotive matters, and has for years been closely identified with the locomotive equipment in Germany. The equipment for which he stands as sponsor is important to Americans just now. His article in this issue of the AMERICAN ENGINEER is timely, because it treats of the four-cylinder balanced compound and superheating.

Professor von Borries uses four cylinders, compounded and in a balanced arrangement, but instead of dividing their efforts between two axles, all four cylinders connect to the same axle, which is cranked. This differs materially from the de Glehn system, and as von Borries' ideas have been embodied extensively into German practice, they are worthy of most careful attention.

The von Borries construction brings the cylinders together. The two valve motions for high and low pressure cylinders are handled as one valve gear from the cab. Professor von Borries claims that connecting all the cylinders to one axle subjects that axle to very little more stress than that of de Glehn's arrangement. The cranked portions receive stresses from the inside cylinders, and those from the outside cylinders are largely transferred through the coupling rods. Von Borries makes a strong point of balancing the forces of the pistons and reciprocating parts on one axle because of its effect upon the wearing and knocking of the driving boxes, due to horizontal lost motion from wear of the brasses. He supports this view by comparisons of mileage between shoppings of engines on his system and de Glehn's, arguing that the freedom from wear of the driving boxes affected the tire wear favorably, and thus greatly increased the period between shoppings and consequently the cost of repairs. Professor von Borries says that his engines do not develop knocking in the boxes in mileages as high as 45,000. I did not ride on one of these engines, but am informed that they run very smoothly, thus confirming the claim referred to.

Professor von Borries is a painstaking student of valve motion and steam distribution, and is not one to turn aside from complication if he thought he could gain by it. He prefers to fix the proportions of expansion by connecting the reversing motions of both high and low pressure cylinders to the same reversing gear than to use the separate adjustment method of the de Glehn system. In support of this he cites performance records to show that the engineers in Germany do not use the separate valve gear to the best advantage. He may be entirely right in this, but my observations on the de Glehn compounds on the Northern Railway of France lead me to believe that the best locomotive arrangement is not too good, and that the men should be educated up to the best. I do not believe American locomotive engineers are up to handling either the von Borries or the de Glehn systems, but so much the worst for our railroads. The best system should be used, and the men should be educated up to it. I believe the von Borries engines, if the men were perfect, would be more efficient with separate control of the valve gears.

In France piston valves do not seem to be in high favor, and Mr. de Glehn heartily disapproves of them. Herr von Borries disagrees with him, and prefers piston to slide valves for high pressure cylinders. He uses piston valves for high pressure and slide valves for low pressure cylinders, driving both by the same valve motion on each side of the engine.

The von Borries, like the French and English locomotives, are beautifully designed. The careful work of the drawing room is shown, especially in such details as the valve gear, main and side rods. These appear absurdly light, compared with ours, but they never break. What they would do on our roads, where 4-in. shims are required under the rails in winter, is another question. They are unquestionably well adapted to the conditions under which they work.

My impression is that the Germans have sought accessibility to a greater extent than the French. They do not hesitate to complicate construction where it is desirable. They, however, do not willingly admit that they can learn much from France, and in this they are not alone. They can certainly learn much (and so can every other country I visited) from France in the handling of fast passenger locomotives. The prejudices of patriotism should break down before a matter of so great import as the study of transportation methods.

G. M. B.

(*To be continued.*)

WEIGHT OF A CROWD OF PEOPLE.—Authorities and building laws differ as to the weight per square foot to be allowed for a crowd of people. Some have put it as low as 40 lbs. and others as high as 150 lbs. In order to satisfy himself of the possible weight for floors and bridges, Mr. Lewis J. Johnson recently made some experiments, and described them in the *Journal* of the Association of Engineering Societies in January, 1905. His greatest load was 181.3 lbs. per ft., and was obtained by packing 40 men, averaging 163.2 lbs. each, into a space 6 ft. square.

SIDE DOOR SUBURBAN PASSENGER CARS.

ILLINOIS CENTRAL RAILROAD.

Sixteen of the Sullivan-Renshaw cars illustrated in this journal on pages 204, 327 and 358 of the volume for 1903 are now in the suburban service on this road, where they have displaced 32 wooden cars of the type heretofore exclusively used. The cost of repairs of the new cars has been very low; they have furnished absolute protection from personal injury of passengers and the stops are marvelously short. These facts and other information concerning these cars are contained in a communication from Mr. A. W. Sullivan, now general manager of the Missouri Pacific Railway, who, when with the Illinois Central, designed these cars with Mr. W. Renshaw, superintendent of motive power of that road.

In the cars last built and put in service last fall, the details of the appointments have been perfected, so that they are now complete in every particular, and are working with great smoothness and efficiency.

In a recent stop watch test of the time required in making a local run with a 8-car train carrying 450 passengers, the following record was obtained; the time being taken from the moment the train came to a full stop until it started, during which interval, at each station, the side doors were unlocked, opened, the passengers discharged and admitted to the train, the doors closed and locked.

Stations.	Time of stop.	Stations.	Time of stop.
16th st.	7 sec.	47th st.	12 sec.
22d st.	5 sec.	50th st.	9 sec.
26th st.	6 sec.	53d st.	10 sec.
31st st.	8 sec.	57th st.	6 sec.
36th st.	12 sec.	60th st.	5 sec.
39th st.	7 sec.	63d st.	3 sec.
43d st.	9 sec.		

The average time of the 13 stops was 7.61 seconds. This test was made without the knowledge of the train crew, and there was therefore no different handling from that which ordinarily obtains in the service.

The cars have been in regular daily service now for a period of 19 months, including two of the most severe winters on record in Chicago. Notwithstanding the extreme cold weather and the severe storms to which the Illinois Central trains are exposed by reason of the location of the railroad for a distance of 7 miles along the shore of Lake Michigan, the cars have at all times been kept comfortably warm, with a much less consumption of steam than required in the end-door cars performing the same service.

The impossibility of any one getting on or off the cars, or in any manner attaching themselves to the train while in motion, has eliminated personal injuries as a factor of the service

The electric train signal, with which all the side door cars are equipped, has been in continuous use for over a year, and has worked most satisfactorily throughout the severe weather of the past winter. By the use of this signal the trainmen are relieved from giving the signal, by passing it from one to the other, from the rear of the train to the engine. This slow and cumbersome method, fraught with possibilities of mistakes, is entirely eliminated by the electric signal. It is operated automatically by the mere act of the trainman in opening and closing the side doors, and only when the last open door of the train is closed does the engineer get the signal to start, which can then be done instantly with the positive assurance that all the doors are closed and locked.

By this system the trainmen work independently of each other, opening and closing the doors of their cars to suit the requirements of the passengers without reference to what the other trainmen are doing. As the circuit by which the starting signal is controlled can be completed only by the closing of the doors, the last man to close the door practically starts the train. The operation of the signal is instantaneous and can be worked just as effectively on a train of 20 cars as on a train of 2 cars. This electric signal, which is an essential part of the side door scheme of operation, contributes greatly to the quickness and the safety of the results obtained.

The operation of the side door cars has passed the experimental stage, and may now be considered entirely practicable and highly efficient.

From Mr. Sullivan's report to the International Railway Congress on suburban service, the weight and carrying capacity of suburban cars on 23 American railroads are given, from which the following comparison is drawn:

	Number of seats.	Length over endsills of underframe in ft.	Total weight of cars.	Total weight. Per lineal ft.	Total weight. Per seat.
Illinois Central, new cars	100	64	84,600	1,323	846
Average of suburban equipment of 23 American railroads	64.61	52.9	60,925	1,144	942

DANGERS OF PRESENT PASSENGER CAR CONSTRUCTION.

Whether it will be generally admitted or not, the influence of the officials of the United States railway mail service toward improving the end construction of passenger cars is a powerful one, which should receive careful thought among railroad men. Another influence in the same direction is the policy of the Pullman Company in making its cars so strong and heavy that they are sure to survive wrecks in good condition. Postal cars and Pullman sleepers, when strengthened against collision damages, constitute a source of serious danger to other cars in the same train which are not specially reinforced. Recently a wreck in the New York Subway proved the superior strength of a steel car over a wooden one to have been gained at the expense of the wooden one.

It is well enough to argue that cars are supposed to run without accidents, but accidents certainly do occur, and the gradual increase in train speeds is likely to increase rather than decrease the number. Strengthening a few or all cars cannot prevent wrecks, and it is clear that strengthening a few cars increases the danger to passengers when wrecks do occur.

It is clear that all cars must be strengthened so that the force of a collision will not become dissipated by crushing or telescoping. There is nothing mysterious about this. Very simple and satisfactory designs are now in use, employing steel frames and end construction of ample strength. What is the trouble? This may be answered by asking a question. What real improvements have been introduced into the construction (taken as a whole) of ordinary passenger cars during the past twenty years?

The question of a properly designed steel underframe, with specially strong end construction, including friction draft gear, to assist in absorbing shocks, is squarely before the railroads. When some important road brings out a good steel frame passenger car, even if the entire car is not at first of steel, the other roads will tumble over each other to follow suit. It will be interesting to see who will "take the bull by the horns" and meet this emergency. If it is not done soon, by the railroads themselves, legislation and perhaps an amplification of the safety appliance law may be expected as inevitable.

One reason for the lack of progress in passenger cars is that matters of design, and largely also of construction, have been allowed to remain in the hands of the builders, and we have commercial car builders' cars rather than railroad men's cars. But this is the fault of the railroads. It will not do to longer delay, or the public will be heard from in an unmistakable voice. Draftsmen should be set to work at once to build steel frame cars, if not all steel cars. They should begin with clean sheets of paper, and avoid spoiling steel construction by an attempt to bend or adapt it to the methods necessary with wood.

Another construction for American railroad officials to take up is an improvement in the prevailing type of six-wheel trucks, with their vast number of parts.

REPORT OF COMMITTEE ON FREIGHT EQUIPMENT.

ROCK ISLAND COMPANY.

EDITOR'S NOTE.—Simultaneously with the study of the condition of the locomotives of the Rock Island-Frisco System, which resulted in suggesting standard locomotives (AMERICAN ENGINEER March, 1905, page 84) by the power committee, a car committee began an equally elaborate study of the condition of cars, and reported in favor of standards for future construction. This report contains much confidential information, but the portions which are of general interest are presented in abstract by permission of Mr. Robert Mather, chairman of the executive committee.

The committee was instructed,

First.—To make an investigation of the freight equipment of the Rock Island and Frisco systems, and present a detailed statement of the same, together with recommendations looking (a) To the increase in its capacity and usefulness. (b) To the prolongation of its life.

Second.—To prepare standard designs for all classes of cars.

On August 19th and 20th a preliminary meeting was held at the office of the chairman in St. Louis, at which were present Messrs. T. S. Lloyd, general superintendent of motive power, and C. A. Seley, mechanical engineer, representing the Rock Island System; W. A. Nettleton, general superintendent of motive power, representing the Frisco System, and Joseph H. Ames, of the American Car and Foundry Company, chairman, at which the work to be done by the committee was thoroughly discussed and a programme outlined. Following this, Mr. Henry La Rue, master car builder of the Rock Island at Chicago, and Mr. E. B. Schofield, general foreman of the car department of the Frisco System at Springfield, Mo., were detailed by Messrs. Lloyd and Nettleton respectively to act as permanent members of the committee and they, together with the chairman, began on August 25th, an examination in detail of the equipment. This inspection work occupied the committee until September 25th, and during this time practically every type of construction was examined; the condition of the car and recommendations as to its improvement or retirement being discussed and noted at the time of examination.

During the same period the clerical forces of the superintendents of motive power were engaged in compiling lists of the equipment, giving the number of each class of car in service, together with the age, capacity and original cost. Based on these lists, diagrams showing the composition of the equipment and its age, and tables showing the original cost and its present value, after deducting a constant annual depreciation, were prepared. A detailed list of each series of cars with the recommendations of the committee as to its improvement or retirement was also prepared, with tables showing original and depreciated value of equipment that should be retired from service at the earliest practicable date.

It is the opinion of the committee that all equipment of less than 60,000 lbs. capacity is, owing to its age and light construction, not safe to operate in the present heavy trains, owing to its liability to having the draft rigging pulled out, or the sills broken, permitting the car to buckle up or break down, when placed between modern high capacity cars; thereby causing damage to other cars, as well as an interruption to traffic by the wrecking of trains.

Further than this, the ratio of revenue earning load to dead weight hauled is too low for economical operation as compared with cars of higher capacity, being as follows:

Lbs.	Box.	Stock.	Coal.	Flat.
30,000	1.3 :1	1.3 :1	1.6 :1	1.7 :1
40,000	1.6 :1	1.6 :1	1.8 :1	2 :1
50,000	1.3 :1	1.8 :1	2.1 :1	2.5 :1
60,000	1.9 :1	1.3 :1	2.1 :1	2.5 :1
80,000	2.2 :1	None	2.5 :1	2.8 :1

An examination of the records will demonstrate that the principal item of expense for car repairs consists of the maintenance of these light capacity cars, and the early retirement of these cars would accomplish a large reduction in the expenditures for car repairs.

Many of these light cars have come to the systems by the purchase of roads having their own standards for equipment, hence there is a great variety of materials to be carried in stock for their maintenance, and unless a complete assortment is carried at each repair point, delays are sure to occur while waiting for necessary materials to be transferred from one point to another.

The committee recommends the adoption of a standard for every possible part, and whenever cars under repair require the replacement of any or all of such parts, that the standard decided upon be applied, instead of maintaining the original construction, which will gradually reduce the diversity and amount of material now necessarily carried in stock, and simplify and cheapen the work of repairs.

For all equipment constructed in the future, the committee recommends the use of all steel underframe and steel skeleton superstructures; the floor, sheathing, lining and roofing of closed cars and the sides, ends and floors of open cars to be of wood, as the trend of prices for lumber is upwards, and for steel is downwards; therefore, the cost of maintenance of steel cars would be less and of wooden cars would be greater, before the expiration of the useful life of a car built at the present time.

The designs presented by the committee have been worked out with regard for simplicity in original construction and ease in making repairs, as the central idea, and to be as low in dead weight as is consistent with safety.

The capacity recommended for box, furniture, refrigerator, fruit and stock cars is 60,000 lbs., as the conditions of traffic do not justify the use of a higher capacity; 80,000 lbs. for gondola and flat cars, and 100,000 lbs. for hopper or other types of self-clearing cars.

The ratios of revenue earning load to dead weight hauled for cars built to these designs would be as follows: Box, 2.1 to 1; stock, 2.2 to 1; coal, 2.5 to 1; flat, 2.8 to 1.

The maintenance of cars built to these designs would not call for any machinery not already in use in the various shops of the system, commercial sizes of rolled plates and shapes only being employed.

As many of the cars still bear the initials and serial numbers of the roads originally owning them, and therefore many numbers are duplicated, by reason of which there is liability of confustion in reporting cars, the committee recommends that the equipment be classified and renumbered in such a way that the number may indicate the class, and the class symbol the capacity and construction of the car.

(To be continued.)

RESULTS FROM THE COAL TESTING PLANT.

The preliminary report on the coal tests made on the plant of the United States Geological Survey, at St. Louis, contains much information not heretofore available. Among the results already clearly indicated by these preliminary tests the following may be stated as worthy of special consideration:

(1) The tests in the steam-boiler plant of 65 carload samples of coal from 17 states indicate the high steam-producing capacity of American coals, and that the quality of many of these coals may be improved by washing.

(2) Most of the American bituminous coals and lignites can be used as a source of power in a gas-producer plant.

(3) As indicated by comparative tests of 14 bituminous coals from 9 states, the power efficiency of these coals when used in the gas-producer plant is two and one-half times greater than their efficiency when used in the steam-boiler plant; or, in other words, 1 ton of these coals used in the gas-producer plant has developed, on a commercial scale, as much power as 2½ tons of the same coal when used in the ordinary steam-boiler plant.

(4) Some of the lignites from undeveloped but extensive deposits in North Dakota and Texas, when tested in the gas producer and gas engine, have shown unexpectedly high power-producing qualities, such as promise large future developments in those and other states.

(5) Some of the American coals, and the "slack" produced in mining these coals, can be briquetted on a commercial basis.

COMMON STANDARD LOCOMOTIVES.

HARRIMAN LINES.

In July, 1902, a policy of standardization of the entire locomotive equipment of the railroads known as the Harriman Lines was inaugurated. The roads concerned are the Union Pacific, Oregon Short Line, the Oregon Railroad & Navigation Company, Southern Pacific, the Chicago & Alton and the Kansas City Southern, comprising about 18,000 miles, and now operating more than 3,000 locomotives and 90,000 freight cars. The policy is a part of a plan which has been applied by Mr. Harriman in unifying practice, as far as practicable, throughout these lines. The director of maintenance and operation has had charge of the practice included under these heads, and the director of purchases, in conjunction with him and the general managers and the superintendents of motive power of these lines, has standardized all classes of locomotives, freight cars and passenger cars, including every detail. Complete specifications are made standard for locomotives and cars, reducing the purchasing to the simplest possible terms. To indicate the economical advantages of this standardization is the purpose of a series of articles on the complete locomotive standards, these being the most important development of the kind on any railroad. At the present time 366 of the standard locomotives are in service. That these standards are likely to influence the practice of other roads is indicated by the fact that 37 locomotives of the standard 2—8—0 type are now being built for the Erie Railroad.

As a result of the earlier work in this direction by the motive power officials of these roads, a number of standard details were agreed upon, and were illustrated in this journal in June, 1902, page 166. Further development has included so many additional details that the entire subject is now taken up anew, the details having been decided upon after numerous meetings of all the motive power and executive officials.

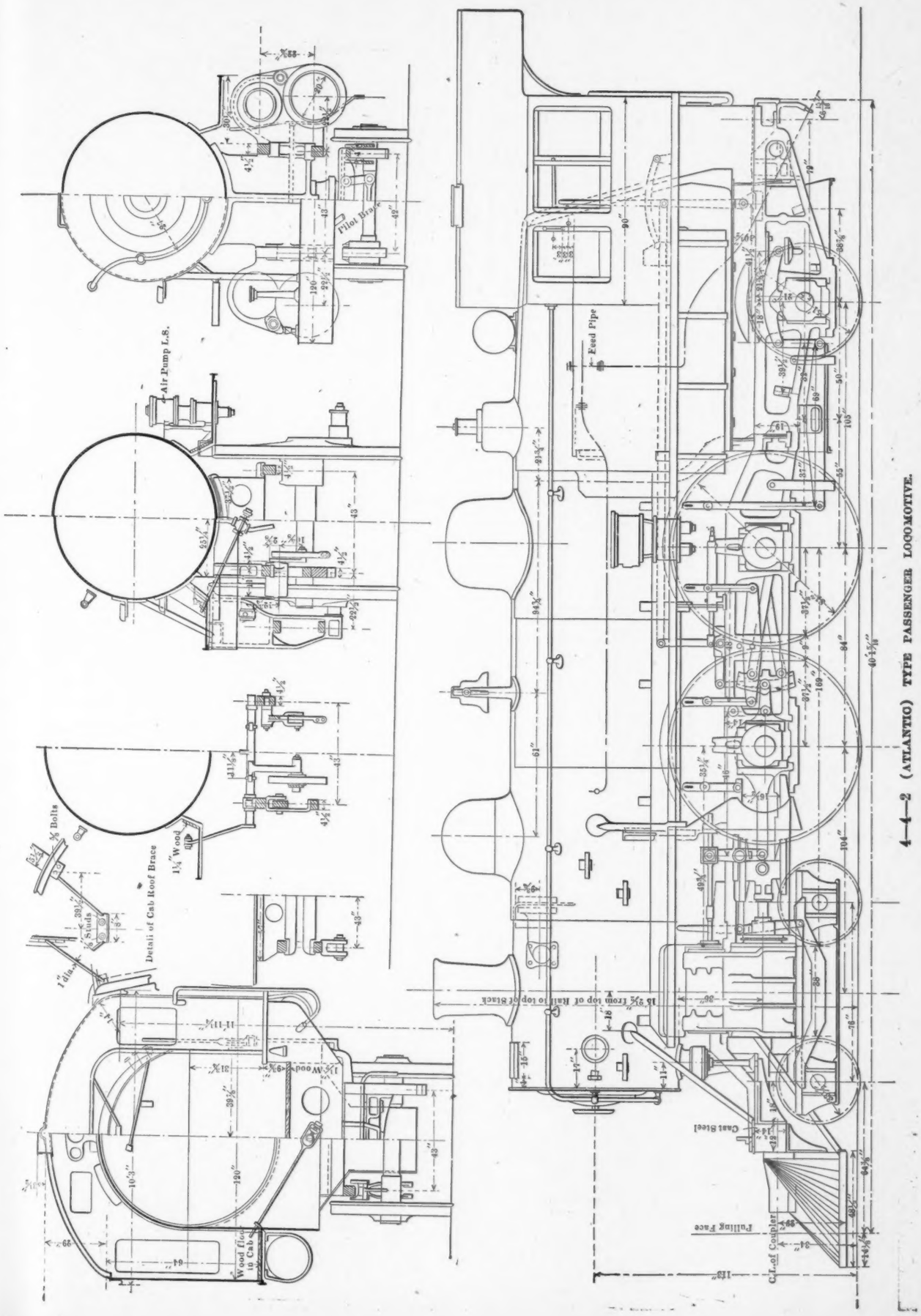
Four types are adopted for future construction, as follows: Atlantic type passenger, Pacific type passenger, consolidation freight and heavy switcher. It is intended to provide for all the demands of the immediate future from these four designs. The existing equipment provides a sufficient number of light locomotives for many years to come. From time to time experimental designs will be tried, with a view of adopting new standards whenever the advantages to be gained thereby are sufficient. For example, an experimental application of the 4-cylinder balanced compound principle is to be made with four locomotives of the 4—6—2 type now building at the Baldwin Works for the Oregon Railroad & Navigation Company.

Side elevations, and sections of the four standard types, together with a list of comparative dimensions and ratios are presented in this article, and discussions of the details will follow. An idea of the scope of the standardization is given in the following summary, which does not attempt to include all of the minor details:

The tenders for passenger engines will have 9,000-gal. tanks and provide for 12 tons of coal. They are of rectangular construction, whereas the freight engines will have Vanderbilt tenders, with cylindrical tanks of 7,000 gals. and 14 tons coal capacity. The switch engines have a special sloping tender of 4,000 gals. and 6 tons coal capacity. The cabs are the same for the various types, modified slightly to fit the different boilers. These will be shown in detail. In general terms,

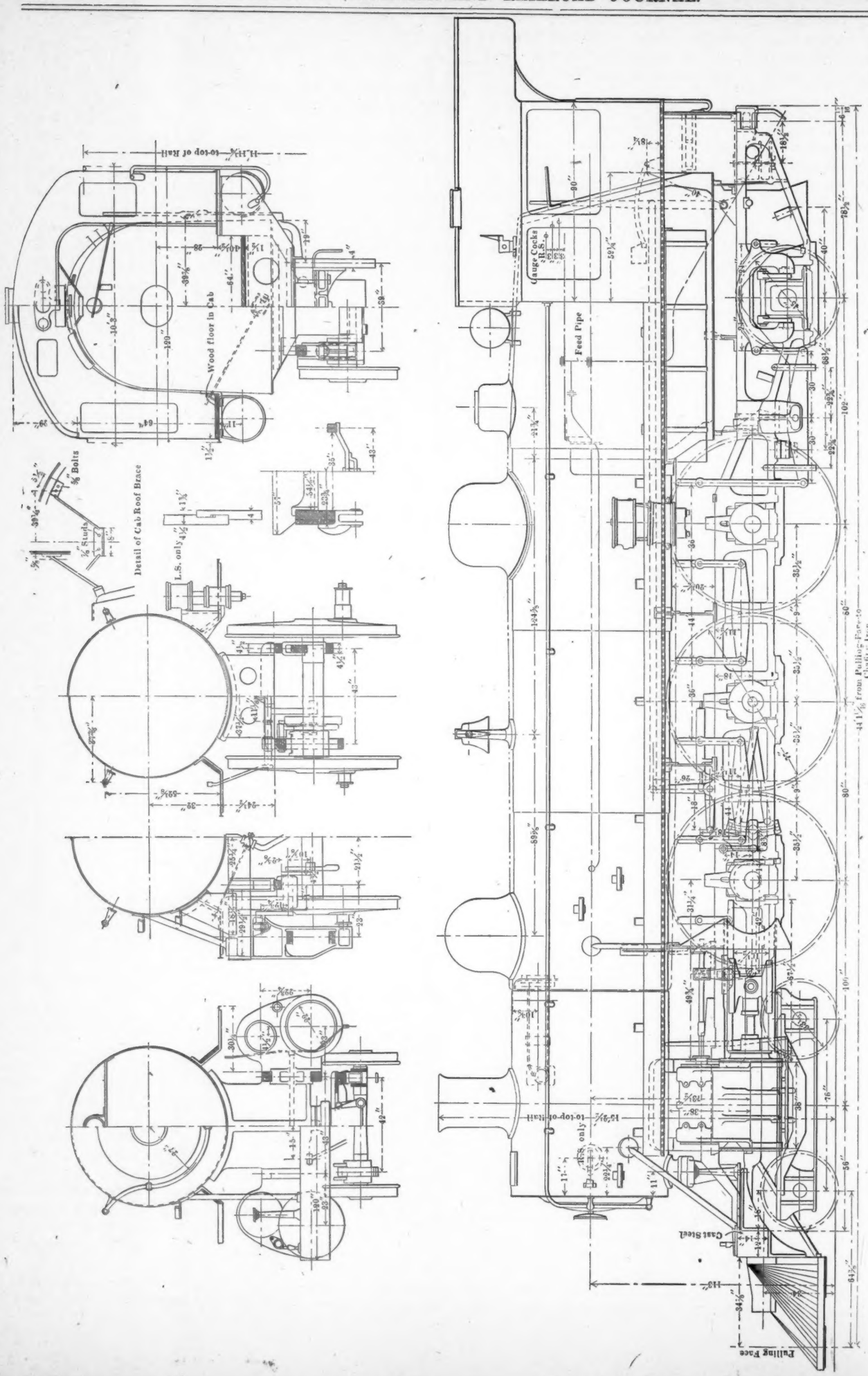
COMMON STANDARD COAL BURNING LOCOMOTIVES.
COMPARATIVE DIMENSIONS AND WEIGHTS.

	Atlantic.	Pacific.	Heavy Consol.	Switch.
Type				
Class	A-105	P-141	C-187	S-150
Common Standard Specification	101	102	103	106
RATIOS—				
Heating surface to volume of cylinder	260.7	248.	270.	179.5
Adhesive weight to heating surface	39.7	46.1	55.	82.
Adhesive weight to tractive effort	4.48	4.7	4.32	5.37
Tractive effort to adhesive weight, per cent	22.2	21.2	23.1	18.2
Tractive effort by diameter of drivers to heating surface	717.	754.	726.	873.
Heating surface to tractive effort, per cent	11.2	10.3	7.84	6.5
Total weight to heating surface	73.	72.	61.	82.
Heating surface to grate area	53.6	61.	69.	60.3
Weight taken with three gauges of hot water, coal fire, sand and two men—				
Weight on front drivers, about	53,000 lbs.	48,000 lbs.	47,600 lbs.	49,100 lbs.
Weight on intermediate drivers, about	.....	.....	45,300 "	53,400 "
Weight on main drivers, about	52,000 "	45,000 "	48,700 "	47,500 "
Weight on back drivers, about	.....	48,000 "	45,400 "	.....
Weight, total, on drivers, about	105,000 "	141,000 "	187,000 "	150,000 "
Weight on truck, about	45,000 "	37,000 "	21,000 "	.....
Weight on trailer, about	46,000 "	44,000 "	.....	.....
Weight, total, of engine, about	196,000 "	222,000 "	208,000 "	150,000 "
Driving wheel base	7 ft.	13 ft. 4 ins.	15 ft. 8 ins.	11 ft. 4 ins.
Wheel base of engine	27 ft. 7 ins.	33 ft. 4 ins.	24 ft. 4 ins.	11 ft. 4 ins.
Wheel base of engine and tender	58 ft. 2 ins.	63 ft. 10½ ins.	55 ft. 11¾ ins.	42 ft. 9 ins.
Height top of rail to top of stack	15 ft. 2½ ins.	15 ft. 2½ ins.	15 ft. 2½ ins.	14 ft. 4½ ins.
Height of cab at eaves above top of rail to center of eave radius	11 ft. 11¼ ins.	11 ft. 11¼ ins.	11 ft. 11¼ ins.	11 ft. 4¾ ins.
Width of cab over shields	10 ft. 3 ins.	10 ft. 3 ins.	10 ft. 3 ins.	10 ft. 3 ins.
Width of cab over eaves	10 ft.	10 ft.	10 ft.	10 ft.
Width over cylinder casing	9 ft. 8¼ ins.	9 ft. 10¼ ins.	9 ft. 10¼ ins.	9 ft. 6¾ ins.
Center line of boiler from top of rail	9 ft. 5 ins.	9 ft. 5 ins.	9 ft. 6 ins.	8 ft. 7 ins.
Center to center of cylinders	88 ins.	89 ins.	89 ins.	88 ins.
Center to center of frames	43 ins.	43 ins.	43 ins.	43 ins.
Cylinders	20 x 28	22 x 28	22 x 30	20 x 26
Driving wheels, outside diameter	81 ins.	77 ins.	57 ins.	57 ins.
Driving wheel centers, outside diameter	74 ins.	70 ins.	50 ins.	50 ins.
Engine truck wheels, diameter	33½ ins.	33½ ins.	30½ ins.	.....
Trailing truck wheels, diameter	51 ins.	45 ins.	.....	.....
Tractive power (M. E. P. 85 per cent. of boiler pressure)	23,506	29,920	43,299	27,915
Fire box	108 in. x 66 in.	108 in. x 66 in.	108 in. x 66 in.	108 in. x 40¼ in.
Grate area, square feet	49.5	49.5	49.5	30.2
Heating surface of tubes, square feet	2,475	2,874	3,266	1,650
Heating surface of firebox, square feet	180	180	171	172
Total heating surface	2,655	3,054	3,397	1,822
Boiler, smallest o. d. diameter, inches	70	70	80	70
Tubes, number and diameter, in inches	297-2	245-2¼	413-2	276-2
Tubes, length, in feet	16	20	15	11½
Boiler pressure, lbs.	200	200	200	180
Valve, type	Piston	Piston	Piston	Am. Bal.
Valve, travel	6 ins.	6 ins.	6 ins.	6 ins.
TENDER, Type	Rectangular	Rectangular	Cylindrical	Rectangular, Sloping
Coal capacity, level full, tons	10	10	14	6
Water capacity, gallons	9,000	9,000	7,000	4,000
Weight of tender, empty	54,400 lbs.	54,400 lbs.	48,720 lbs.	39,770 lbs.
Weight of tender, water carried	75,000 "	75,000 "	58,330 "	33,330 "
Weight of tender, coal carried	20,000 "	20,000 "	28,000 "	12,000 "
Weight of tender, loaded	149,400 "	149,400 "	135,050 "	85,100 "
Weight of tender truck	9,975 "	9,975 "	9,975 "	6,800 "



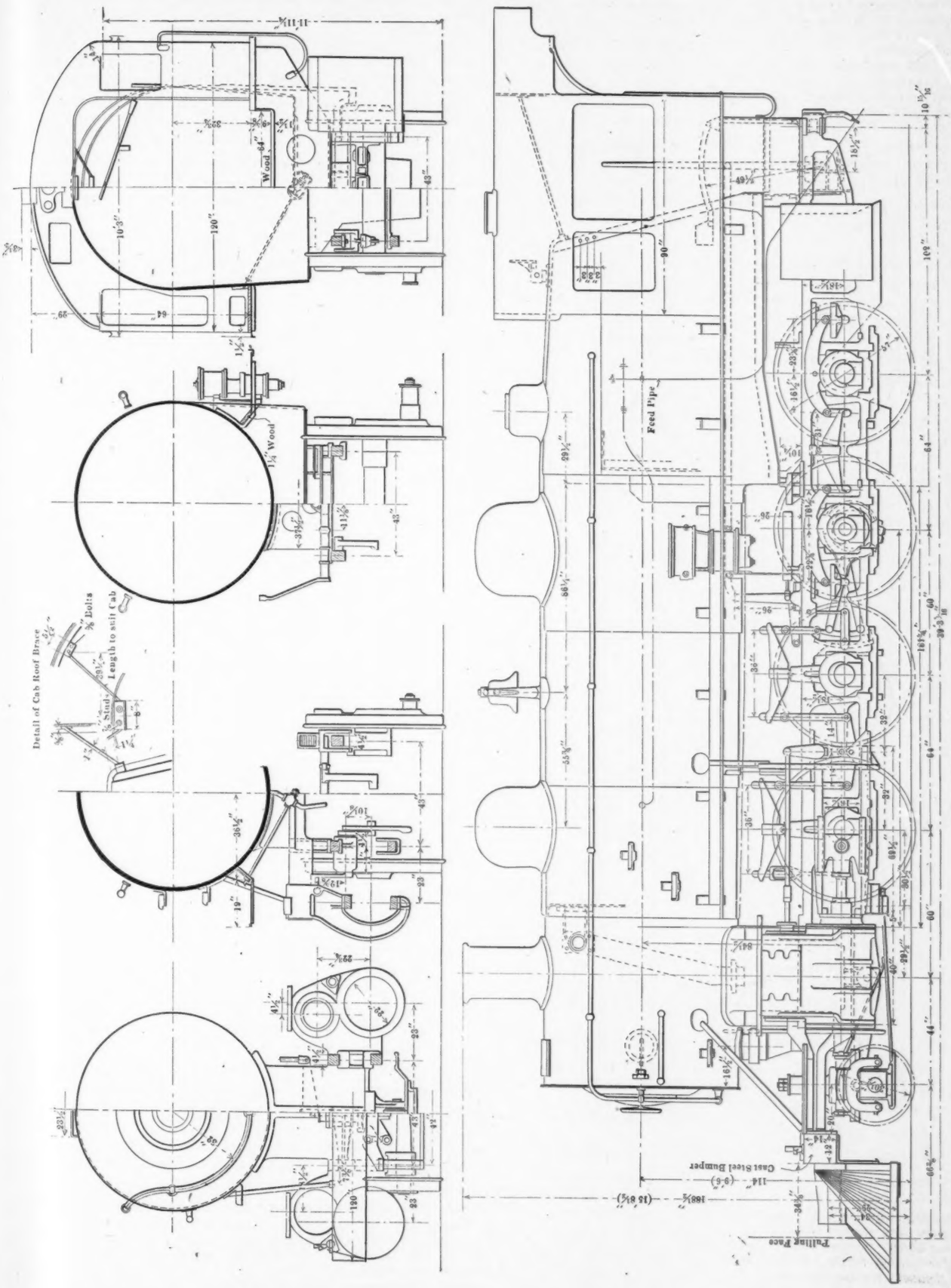
4—4—2 (ATLANTIC) TYPE PASSENGER LOCOMOTIVE.

COMMON STANDARD LOCOMOTIVES, HARRIMAN LINES.



4—6—2 (PACIFIC) TYPE PASSENGER LOCOMOTIVE.

COMMON STANDARD LOCOMOTIVES, HARRIMAN LINES.

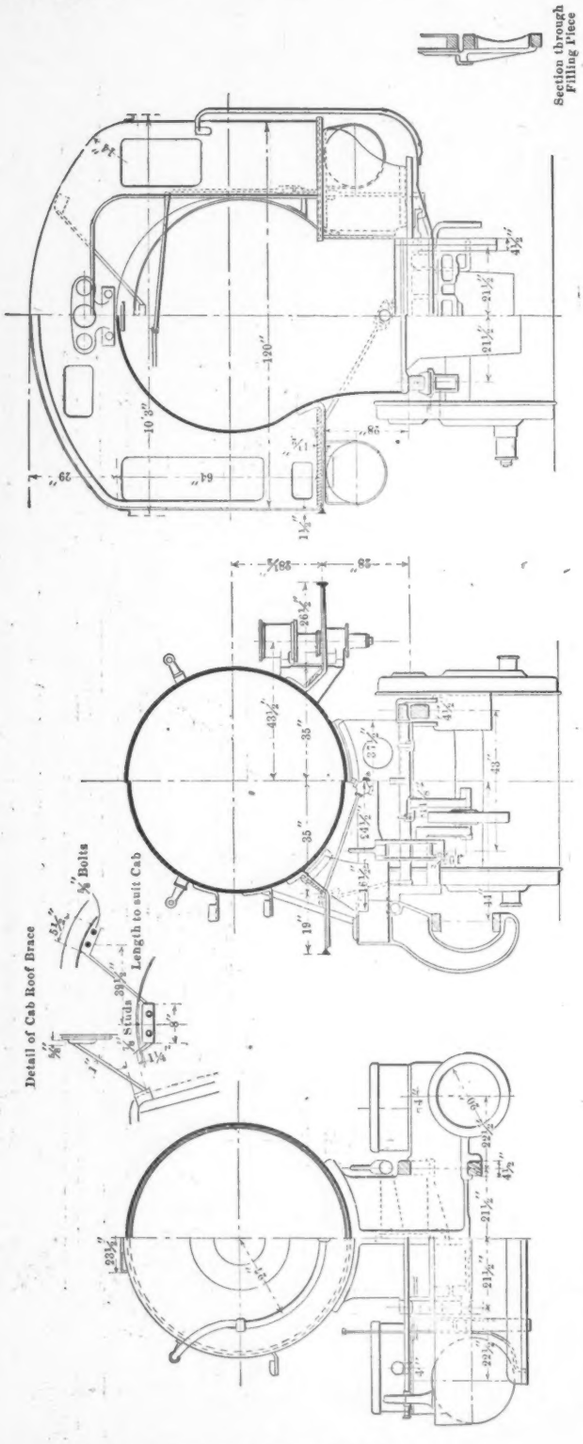


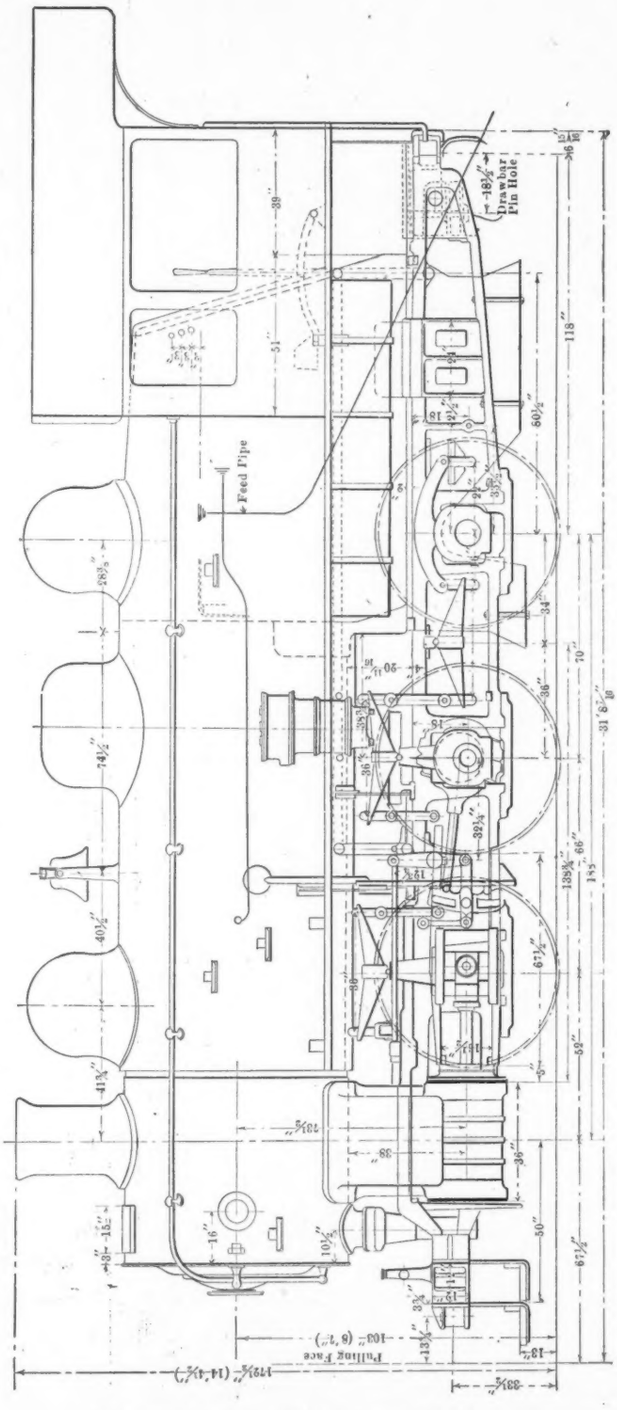
2—8—0 (CONSOLIDATION) FREIGHT LOCOMOTIVE.
COMMON STANDARD LOCOMOTIVES, HARRIMAN LINES.

the following parts are common to all the locomotives, special mention being made of those which are modified for the switch engines:

STANDARDS COMMON TO ALL NEW LOCOMOTIVES.

Driving boxes and brasses.
Locomotive truck boxes and brasses.
Locomotive truck axles.
Smoke stacks.
Bells and sand boxes.
Air bell-ringer.
Pilots (except switchers).
Deck plates.





SIX-WHEEL SWITCHING LOCOMOTIVE.

COMMON STANDARD LOCOMOTIVES, HARRIMAN LINES.

Cast steel front bumpers (except switchers).
Coupling bars (except switchers).
Spring buffers between engines and tenders.
Tender journal boxes (except switcher).
Cab brackets (except switchers).
Cab fittings.
Cinder hoppers.
Exhaust pipes and tips (tips of various sizes).
Cross heads.
Feed-pipe strainers and couplers.

Front journals on main rods.
Front and back journals on side rods.
Crank pin brasses varied as follows:
Back end of main rod (Pacific and Consolidation).
Back end of main rod (Atlantic and Switcher).
Couplers (except front of switcher).
Dome bases, rings and caps.
Headlights.
Auxiliary domes (except switcher).
Cocks, valves and oil cups.
Tank hose (different length on switcher).
Brake shoes.
Eccentrics and eccentric straps.

Steam chest valves. (Piston on road engines. American balance on switcher.)
Grate casting (except switcher).
Piston rods (of 4 ins. in diameter, two lengths).
Piston rod packing (U. S. Metallic).
Valve steam packing (U. S. Metallic).
Links and saddles (radius varies).
Rocker shaft bearings.
Tender truck complete (except switcher).
Throttle valve and throttle dry-pipe ends.

Throttle levers and stuffing boxes.
Safety valves.
Water gauge, Klinger reflex.
Injectors (No. 10 Nathan Monitor road, No. 9 switcher).
Lubricators (Nathan Bull's Eye).
Whistles (chime on passenger, plain on freight).
Smoke box doors.
Steam gauges.
Spring saddles.
Wash-out plugs.

A great many of the minor details which are common to two or more designs and not common to all are not mentioned in this list. The parts listed include all of the most important features of the standardization. In the detailed description the most important parts will be discussed separately.

The courtesy of Mr. W. V. S. Thorne, director of purchases, in supplying this information is acknowledged, and that of the Baldwin Locomotive Works in supplying the drawings.

A SHOP SCHEDULE FOR LOCOMOTIVE REPAIRS.

Mr. Henry Gardner, assistant master mechanic of the Boston & Maine Railroad, has introduced into the Concord shops of that road a shop schedule, which is illustrated by means of the accompanying blank forms:

The object of scheduling or dating locomotive parts in a large railroad repair shop is at once seen when the proper delivery of all the parts needing general repair, for say, 20 or 30 locomotives, is considered. These many parts must, in general, go through the same process for all engines having the same class of repairs, and must follow the same route or course through the various departments. It is evidently out of the question for any one man, however retentive his memory, to follow all this material so that it will be delivered to the erecting shop when needed for the engine, and, therefore, some system must be employed to avoid unnecessary delays.

This system simply assigns to each part of the engine a proper date or day of the month when this part must be sent to, received at, and delivered in turn to the various departments comprising the route over which it is to travel. These parts all start from the erecting shop after the engine is stripped, and return to the erecting shop when wanted for final application.

Sheet No. X.

SCHEDULE SHEET.

Engine No. X. Date taken into Shop, X, '05.
Class, X. Date to leave Shop, X, '05.
Class of Repairs, C. Time allowed, 25 days.

This form contains constants for use in making out the repair record sheets.

Class of Work.	Wanted in Machine Shop.	Wanted in Smith Shop.	Wanted in Boiler Shop.	Wanted in Cab Shop.	Wanted in Paint Shop.	Wanted in Erecting Shop.	Received in Erecting Shop.	Remarks.
Boiler test (first)	..	..	2	..	..	2	..	..
Tender (first)	..	..	4	..	14	4	..	..
Cab	..	..	..	3	..	10	..	..
Valves and Yokes	2	3	..	..	..	10	..	..
Steam chests and covers	2	..	..	..	..	10	..	..
Tender springs	..	..	..	..	..	13	..	..
Spring rigging	..	2	..	..	..	16	..	..
Driver brake	..	2	..	..	..	16	..	..
Guides	2	..	..	..	..	16	..	..
Ash pan	..	..	3	..	..	18	..	..
Driving wheels	1	..	..	..	..	18	..	..
Eccentrics and straps	2	..	..	..	..	18	..	..
Cross-heads	2	..	..	..	..	19	..	..
Pistons and rods	2	..	..	..	..	19	..	..
Engine springs	..	..	..	..	..	19	..	..
Driving boxes, shoes, wedges	2	..	..	..	..	20	..	..
Link work	2	..	..	..	..	20	..	..
Main rods	0	..	..	..	..	20	..	..
Brass work	2	..	..	..	..	20	..	..
Flues set	..	..	20	..	..	20	..	..
Boiler work	..	..	20	..	..	20	..	..
Engine truck	..	..	..	..	..	20	..	..
Boiler test (last)	..	..	21	..	..	21	..	..
Smokebox work	..	..	22	..	..	22	..	..
Tender (last)	..	..	..	..	..	23	..	..
Parallel rods	0	..	..	..	..	23	..	..

The blank forms include a schedule sheet, date sheet, repair record sheet and shop repair cards. The date sheet or "Calendar" is used to quickly and accurately assign the dates as called for on the repair record sheet. This is done by means of the schedule sheet, which carries against the parts to be routed, numbers or constants, representing the increments of time between the receipt and delivery of these parts in the various departments concerned. The date sheet may be made for any number of months, and is merely a convenient aid in making out the repair record sheet. It may be made in the form of a slide rule, with the days of three months (Sundays and holidays omitted) on the fixed part, and numbers from 0 to 24, or the total number of days in the schedule on the sliding part. The 0 is placed under the day an engine comes into the shop and over the constants on the sliding part, the desired date when parts must be ready is read from the fixed part.

The schedule sheet is a counterpart of the repair record sheet but, instead of carrying actual dates, the corresponding spaces are used for the constants referred to. An engine may be allowed any number of days, the values of the constants varying in proportion to the total time.

The repair record sheet shows the names of the parts in the left-hand vertical column, and on the horizontal line at the top are headings for each department concerned. The shop repair card is a subdivision of the repair record sheet, and is used to extend the information on that sheet to the workmen who make the repairs to the different parts.

Sheet No. 201.

REPAIR RECORD SHEET.
issued to
JOHN SMITH, Foreman.

Engine No. 2. Date taken into Shop, 2—27—'05.
Class T—84—c. Date to leave Shop, 3—27—'05.
Class of Repairs, C. Time allowed, 25 days.

Class of Work.	Wanted in Machine Shop.	Wanted in Smith Shop.	Wanted in Boiler Shop.	Wanted in Cab Shop.	Wanted in Paint Shop.	Wanted in Erecting Shop.	Received in Erecting Shop.	Remarks.
Boiler test (first)	....	....	3–1	....	....	3–1	....	....
Tender (first)	....	....	3–3	....	3–15	3–3	....	....
Cab	....	....	....	3–2	....	3–10	....	....
Valves and yokes	3–1	3–2	....	....	....	3–10	....	....
Steam chests and covers	3–1	....	....	....	....	3–10	....	....
Tender springs	....	....	....	....	....	3–14	....	....
Spring rigging	....	3–1	....	....	....	3–17	....	....
Driver brake	....	3–1	....	....	....	3–17	....	....
Guides	3–1	....	....	....	....	3–17	....	....
Ash pan	....	....	3–2	....	....	3–20	....	....
Driving wheels	2–28	....	....	....	....	3–20	....	....
Eccentrics and straps	3–1	....	....	....	....	3–20	....	....
Cross-heads	3–1	....	....	....	....	3–21	....	....
Pistons and rods	3–1	....	....	....	....	3–21	....	....
Engine springs	....	....	....	....	....	3–21	....	....
Driving boxes, shoes, wedges	3–1	....	....	....	....	3–22	....	....
Link work	3–1	....	....	....	....	3–22	....	....
Main rods	2–27	....	....	....	....	3–22	....	....
Brass work	3–1	....	....	....	....	3–22	....	....
Flues set	....	....	3–22	....	....	3–22	....	....
Boiler work	....	....	3–22	....	....	3–22	....	....
Engine truck	....	....	....	....	....	3–22	....	....
Boiler test (last)	....	....	3–23	....	....	3–23	....	....
Smokebox work	....	....	3–24	....	....	3–24	....	....
Tender (last)	....	....	....	....	....	3–25	....	....
Parallel rods	2–27	....	....	....	....	3–25	....	....

This Sheet, to be returned to the Master Mechanic's Office when the Engine goes into service.

F. E. BROWN, M. M.

These sheets and cards are used in the following manner in these shops, although, of course, no two shops would employ the same methods, due to the differences in arrangement and classification of buildings and machines. The repair record sheet is first filled out by the master mechanic, and issued to the foremen of the different departments; each foreman receiving a duplicate sheet bearing all dates for the entire engine. From this each foreman issues the shop repair cards to the head men on the different jobs, or classes of work, which come under his jurisdiction. At Concord 12 of these cards

are issued for each engine, covering practically all parts as given on the repair record sheet.

In filling in the dates, for example, the "main rods" on the repair record sheet for Engine No. 2 are wanted in the machine shop February 27 (2—27), and in the erecting shop ready for the engine, 3—22. Referring to the schedule sheet for 25 days (the number of days allowed this engine), the constant 0 is found in the corresponding space for "main rods" "wanted in machine shop," and the constant 20 is found in the space for "main rods" "wanted in erecting shop." Turning to the date sheet (or slide rule), put 0 under the date 2—27, when the engine came in, and on the same horizontal line in numerical order write the numbers from 0 to 24, or one less than the total number of days given by the schedule.

1905. No. 748.

SHOP REPAIR CARD.

Issued to F. E. RICHARDS, Foreman. Engine No. 2.

Class of Work	Wanted in Erecting Shop. (First.)	Wanted in Paint Shop.	Sent to Paint Shop.	Wanted in Erecting Shop. (Last.)	Remarks.
Tender	3—3	3—15	....	3—25	.....
Engine truck. ..	....	.....	....	3—22	.....

This card to be filled out and returned to the Foreman's Office and then sent to the Master Mechanic's Office at once.

JOHN SMITH, Foreman.

1905. No. 802.

SHOP REPAIR CARD.

Issued to M. ANDERSON, Foreman. Engine No. 2.

Class of Work	Wanted in Cab Shop.	Received in Cab Shop.	Wanted in Erecting Shop.	Wanted in Paint Shop.	Date Finished.
Cab and Run. Boards	3—2	....	3—10	.....	.....
Tender	....	....	3—3	3—15	.....

This card to be filled out and returned to the Master Mechanic's Office at once. Write any explanation on back of card.

F. E. BROWN, M. M

1905. No. 2,014.

SHOP REPAIR CARD.

Issued to W. JONES. Engine No. 2.

Class of Work.	Wanted in Machine Shop.	Received in Machine Shop.	Wanted in Erecting Shop.	Date Finished.	Remarks.
Valves	3—1	....	3—10	....	.....
Yokes	3—1	....	3—10	....	.....
Steam chests	3—1	....	3—10	....	.....
Steam chest covers	3—1	....	3—10	....	.....
Guides	3—1	....	3—17	....	.....

This card to be filled out and returned to the Foreman's Office, and then sent to the Master Mechanic's Office at once.

JOHN SMITH, Foreman.

Then, reading up over 0, the date 2—27 and, reading up over 20, the date 3—22 is found. It will be seen that Sundays and holidays are omitted, since working days only are considered. In the same manner the proper date corresponding to a constant of any value from 0 to 24 may be quickly read from this sheet (or slide rule).

The values of the constants on the schedule sheet were obtained by comparing records of the average time required to do each class of work. These results were then checked and altered as necessary to produce the best results in practice. Each engine of a class should have the same schedule.

The column "Remarks—Cause for Delay, Etc." on the repair record sheet may be omitted after the repairs are running smoothly in their allotted times. On first using this system, however, these causes for delay, if honestly given by the foremen, will greatly help to equalize the shop, that is, to bring up a weak department by adding men or machines, as necessary. In this manner an equilibrium can finally be obtained which will produce the best results. The column headed "Received in Erecting Shop" is filled in by the erecting shop foreman as the work is received.

A few apparent advantages resulting from using this system are given as follows:

(1) The shops may be equalized, as already stated, departments deficient in men or tools may be adjusted or balanced to produce the best results. (2) Friction between foremen and sub-foremen in different departments may be avoided, since the shop repair card dictates when any part will be finished and delivered. (3) The men are stimulated in their work from the fact that some take an interest in keeping their dates, while others have continually the knowledge that delays in their department are known and recorded at headquarters. (4) The increased output always noticeable where systematic methods are employed for doing work.

The schedule of the Chicago & Northwestern Railway at Chicago was illustrated in this journal in February, 1904, page 58, and in March, 1905, page 73, some of the results obtained by its use were recorded.

TIRE STEEL INSUFFICIENTLY WORKED.—In an admirable paper before the International Railway Congress, Mr. P. H. Dudley shows from an exhaustive study that tire steel is inferior to rail steel in wearing qualities because it is not sufficiently worked. It has a "cell hardness," instead of a "mass hardness," and lacks the interlocked and fine structure of rail steel. While greater care is taken with tire than with rail ingots, still more attention is necessary to secure the desired solidity, first in the ingots, and second, in the manufacture. This is evident from failures of trailing wheel tires of Atlantic type engines, with loads of 38,000 lbs. per axle. These tires have flattened from crushing, due to slight porosity and unsoundness. These tires are made from 12-sided ingots, in the angles of which unsoundness developed in cooling. They contained 0.62 to 0.67 of carbon, 0.65 to 0.78 of manganese, 0.20 to 0.26 silicon and 0.06 phosphorous. They were hard on the surface from working, but coarse and fragile beneath. The weakness corresponded to some of the corners of the ingots. Trailing tires of 50-in. do not show as good results as 79-in. driving tires on the same engine, because the smaller tires received less work in manufacture. After wear begun its destruction was rapid and dangerous to the track. Tensile tests of small test ingots do not lead to securing the grade of steel desired in tires of varying diameters.

DIFFERENTIAL PIECE RATE SYSTEM.—The differential rate system consists in fixing for any piece of work two rates, one about 20 per cent. higher than the other. If the work is done in the time in which the study indicates that a good man fitted for the work and working at his best normal speed can do it, or in less time, the rate paid is the high one. If the time taken is longer than this, the lower rate is paid. To take a concrete example, let us suppose that a man can turn ten axles in a day on a certain lathe and the high rate is 30 cents each. If nine or less are done he gets only 25 cents each. His pay then for 10 is $3 and for 9 $2.25. The difference between the pay for 9 and that for 10 is thus so great that a workman will make every effort to do the 10 if he has a fair chance of success.—*H. L. Gantt, in Engineering Magazine.*

SMALL THINGS BOUGHT BY RAILROADS.—The Santa Fe uses every year one and a half tons of pins, 25 miles of lead pencils, 396,000 steel pens, 50 barrels of ink, 13,000 lbs. of rubber bands, 15 carloads of stationery, 26,000 brooms.

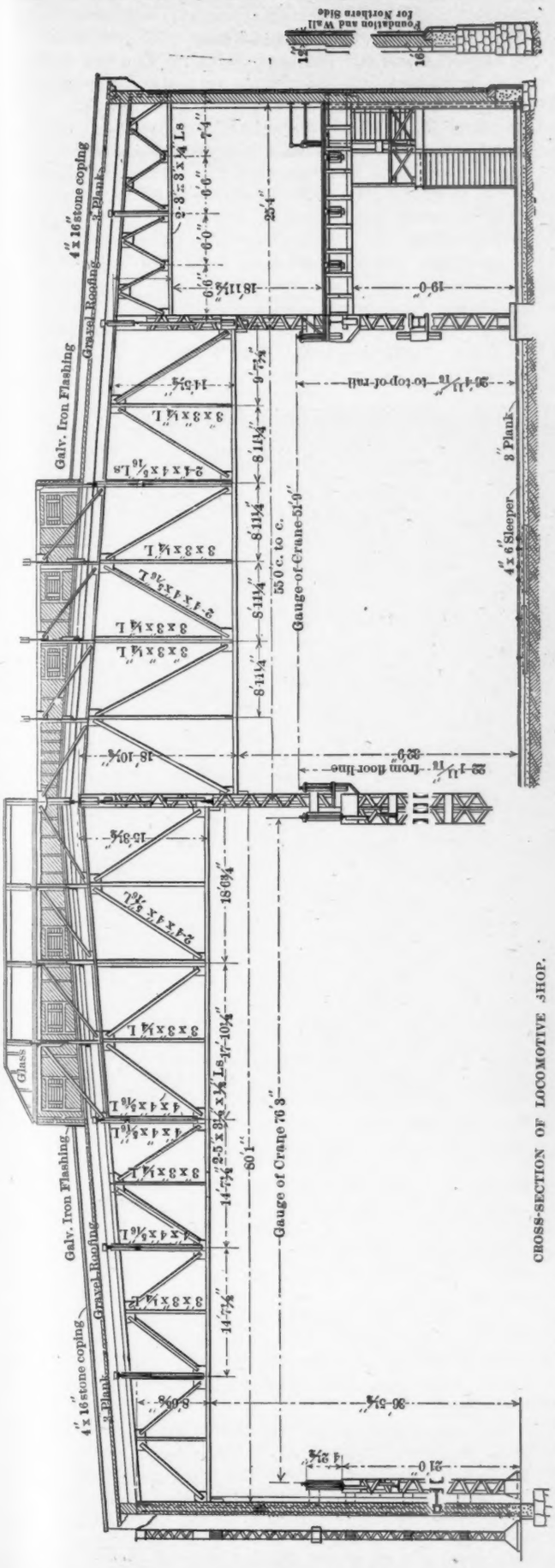
ANGUS LOCOMOTIVE SHOPS, MONTREAL.

CANADIAN PACIFIC RAILWAY.

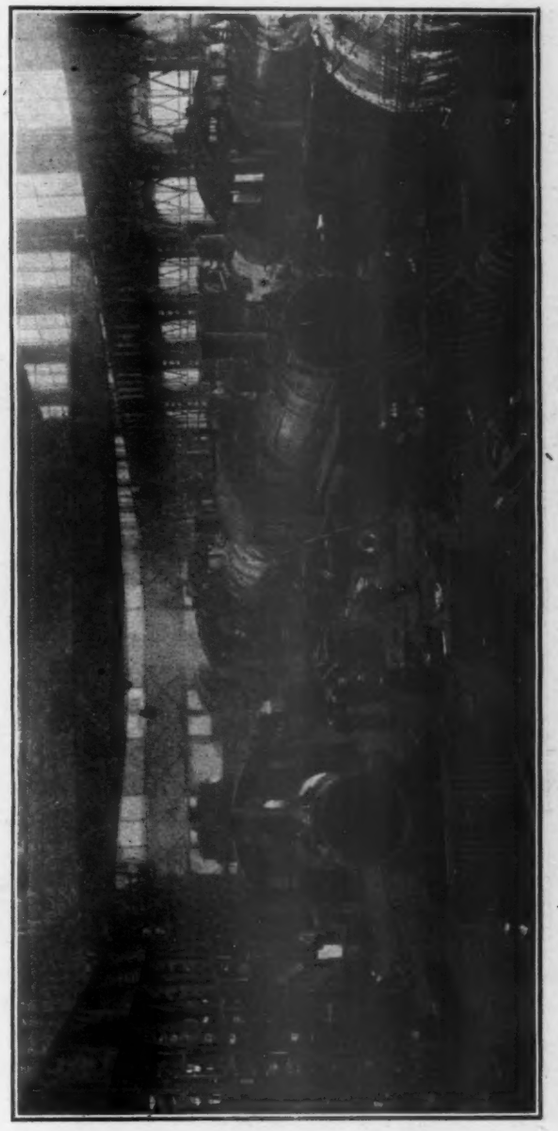
VI.

(*For previous article see page* 114.)

The erecting, machine and boiler departments are provided for in a building 1,167 ft. long by 162 ft. 8 ins. wide, a cross-section and plan of which are shown in the accompanying engraving, to which are added several interior views. The erecting shop is a bay 80 ft. wide; the machine shop is a bay 55 ft. wide, and at one side the full length of the shop is a



CROSS-SECTION OF LOCOMOTIVE SHOP.



INTERIOR OF LOCOMOTIVE SHOP, SHOWING ERECTING BAY.
ANGUS SHOPS—CANADIAN PACIFIC RAILWAY, MONTREAL.

25-ft. gallery, with corresponding space on the main floor. The following table presents general figures:

Floor area, locomotive shop	190,384 sq. ft.
Erecting shop, length	770 ft.
Erecting shop, width	80 ft.
Erecting shop, floor area	61,600 sq. ft.
Arrangement of pits	longitudinal
Available number of pits	36
Area erecting shop per pit	1,711 sq. ft.
Machine shop, length	770 ft.
Machine shop, width	80 ft.
Machine shop, floor area, including gallery	62,575 sq. ft.
Total number of machines	245
Total floor area per machine	255 sq. ft.
Machine shop area per pit	1,738 sq. ft.
Boiler shop, length	395 ft.
Boiler shop, width	80 ft.
Boiler shop, floor space	31,600 sq. ft.
Boiler shop, number of machines	39
Boiler shop, floor area per erecting shop pit	877 sq. ft.

The plan of the locomotive shop is shown in three sec-

tions. In the lower portion of the engraving are the three longitudinal tracks extending through the shop, which are located at 25-ft. centers, which is an unusual distance between tracks. This necessitates an erecting shop bay with a crane span of 76 ft. 3 ins. Between the pit tracks are two standard gauge supply tracks. In the plan the lower, or southern, track has a pit 762 ft. long. The center track has a pit 894 ft. long, and the upper track a short pit 454 ft. long, making a total pit length of 2,110 ft. For convenience in getting about the engines the standing space in the erecting shop is limited to about 36 engines, although this number is somewhat elastic. The building is lighted by high windows and by long transverse skylights over its central portion. The roof trusses and crane supports are illustrated in the sectional view. For protection against fire the entire building is equipped with automatic sprinklers, and galvanized iron fire curtains are built in the roof trusses down to a point which will clear the cranes. These are placed at every seventh roof truss.

millers and the truck wheel and axle box work. A bracket jib crane of 1,500 lbs. capacity, with a pneumatic cylinder, serves the axle work. Two 1,000-lb. pneumatic cylinder bracket cranes handle work to the millers, and planers and truck wheel tires. A 1,000-lb. pneumatic jib crane serves the axle box work, and a 4-ton pneumatic cylinder hand travelling crane is located over the lye cleaning tank. Special care was taken to plan the shop for convenience in handling material, which is a matter of great importance in a plant of this size.

By referring to the floor plan, the departments beginning at the east end of the machine floor are as follows: The wheel shop, including the tire setting, driving box work, truck shop, cylinder shop, piston cross-head department, opposite which is the frame shop; the next space is for side rods, and beyond this motion work. Next comes spaces for miscellaneous departments, such as air pumps, pipe shop, track and spring shop, scale repair shop, some of the latter departments being in the west machine shop. West of this is the boiler shop, providing for flue work and general boiler work, including

INTERIOR OF MACHINE SHOP, SHOWING TRANSVERSE BENCHES AND ROD RACKS.

ANGUS SHOPS, CANADIAN PACIFIC RAILWAY, MONTREAL.

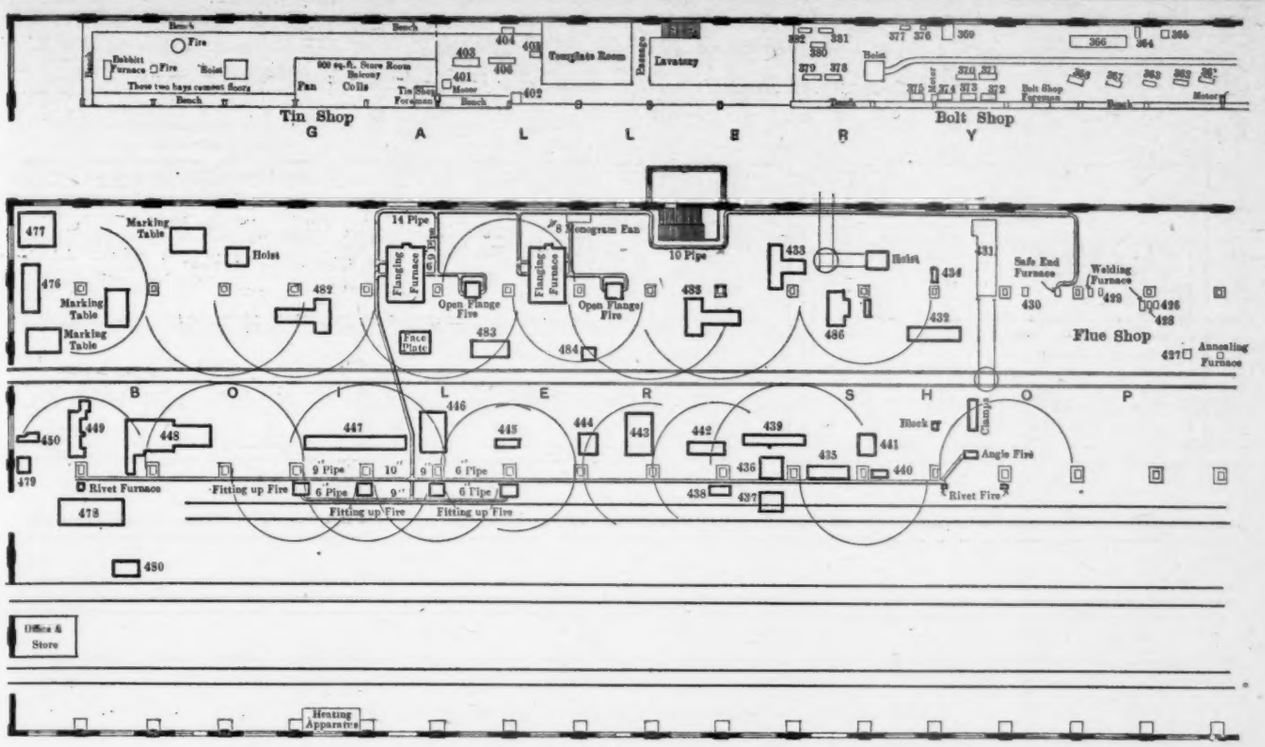
In addition to the tracks in the erecting shop, the machine shop has a supply track running its full length, and the shops have seven transverse supply tracks connected with an out-of-door track running the full length of the building. By the addition of light rails a double narrow gauge track is provided by using one of the light rails and one of the standard gauge rails on each side in an arrangement permitting small trucks to pass each other in opposite directions without switching either of the trucks to the side track. This arrangement is a novelty, which was described in detail in this journal in July, 1904, page 264. These extra rails are also provided for on the shop turn-tables.

The crane facilities are admirable; besides the large 60-ton cranes in the erecting shop, the 15-ton cranes in the machine shop and the 20-ton crane in the boiler shop, a 5-ton overhead travelling crane serves the truck shop. Five-ton jib cranes, one electric and the other pneumatic, serve the tire setting and wheel press work. Three 2-ton cranes, with pneumatic cylinders, serve the boring mills, planers and horizontal

flanging furnaces, flanging machinery, riveters, pipe bending rolls, plate planers and other boiler shop machinery, all of which is included in the complete table of machinery of this department, which forms a part of this description. The boiler shop is well arranged, and has plenty of room between the machines.

This tool list is complete and has been revised to date. The floor plan, showing location of machinery, has also been revised, showing a number of changes from the original locations. These plans have been prepared specially for this description.

The stripping is done at the east or right hand end of the shop, as shown in the plan. When a locomotive is stripped the boiler is taken directly to the boiler shop, the trucks go to the truck department, where two men, by the use of the 2-ton travelling cranes, attend to all the engine truck repairs. The truck shop is reached by the first transverse track, and over this same track all parts requiring cleaning are taken to the lye vats outside of the main building. The driving wheels



PLAN OF WEST END OF LOCOMOTIVE SHOP, SHOWING BOILER SHOP AND GALLERY.

ANGUS SHOPS, CANADIAN PACIFIC RAILWAY, MONTREAL.

BOILER SHOP.

Power Machines.

Mach. No.	Name.	Size.	Maker.	Motor. H. P. & Type.
426	Swedging Hammer		Can. Pac. Ry.	Com. Air.
427	Tube Cutter		Can. Pac. Ry.	15 A.C.
428	Welding Machine		Hartz	15 A.C.
429	Welding Machine		Hartz	15 A.C.
430	Tube Cutter		Can. Pac. Ry.	15 A.C.
431	Tube Cleaner		Whiting Fdry. Co.	20 A.C.
432	Punch and Shears	Size "D"	Long & Allstatter	15 A.C.
433	Punch and Shears		Bertram	10 A.C.
434	Rotary Shears	¼-in. plate	Collier Co.	5 A.C.
435	Double Drill		Bertram	20 A.C.
436	Double Bolt Cutter.	Acme 1½-in.	Bertram	20 A.C.
437	Triple Bolt Cutter.	Acme 1½-in.	Bertram	20 A.C.
438	Vertical Drill	36-in.	Bertram	20 A.C.
439	Plate Planer	18-ft.	Craven Bros.	20 A.C.
440	Vertical Drill	24-in.	Smith & Coventry	20 A.C.
441	Mud Ring Drill	4 Spindles	Craven Bros.	20 A.C.
442	Small Plate Rolls.	8 in.x7 ft.	Craven Bros.	20 A.C.
443	Flue Sheet Drill	2 Spindles	Bertram	7.5 A.C.
444	Flue Sheet Drill	2 Spindles	Craven Bros.	7.5 A.C.
445	Horizontal Punch		Berry & Co.	7.5 A.C.
446	Flue Sheet Drill	3 Spindles	Bertram	5 A.C.
447	Plate Planer	25-ft.	Bertram	15 A.C.
448	Large Plate Roll.	16 in.x12 ft.	Bertram	30 A.C.
449	Mud Ring Drill	6 Spindles	Bement Miles.	7.5 A.C.
450	Vertical Drill	36-in.	Bertram	3 A.C.
451	Small Punch and Shears			30 A.C.

Hydraulic Machines.

476	Steam Pressure Pump.	Duplex 4 in. x 18 in. plungers	Snow Pump Works.	
477	Accumulator	1,500 lbs. per inch	R. D. Wood & Co.	
478	Gap Riveter	17 feet	R. D. Wood & Co.	
479	Crane Cylinder for 478		R. D. Wood & Co.	
480	Portable Gap Riveter.	6 feet	Bement Miles.	
481	Mud Ring Riveter		Fielding & Platt.	
482	Punch and Shears		Fielding & Platt.	
483	Sectional Flanger		Bement Miles.	
484	Press for Small Work			
485	Punch and Shears		Fielding & Platt.	
486	Multiple Punch		Bement Miles.	
487	Tank Riveter		Fielding & Platt.	
488	Mud Ring Riveter		Bement Miles.	

BOLT DEPARTMENT.

361	Turret Lathe	2 in.x26 in.	Pratt & Whitney.	20 A.C.
362	Turret Lathe	2 in.x24 in.	Jones & Lamson.	20 A.C.
363	Turret Lathe	2 in.x24 in.	Jones & Lamson.	20 A.C.
364	Hacksaw			20 A.C.
365	Oil Separator		Niles-B.-Pond	20 A.C.
366	Bolt Lathe			20 A.C.
367	Turret Lathe	2 in.x26 in.	Jones & Lamson.	20 A.C.
368	Turret Lathe	1½ in.x18 in.	Pratt & Whitney.	20 A.C.
369	Bolt Cutter	3-Spindle	Acme.	20 A.C.
370	Bolt Lathe		Can. Pac. Ry.	20 A.C.
371	Bolt Lathe		Can. Pac. Ry.	20 A.C.
372	Bolt Lathe		J. H. Johnston.	20 A.C.
373	Bolt Lathe		J. H. Johnston.	20 A.C.
374	Bolt Lathe		J. H. Johnston.	20 A.C.
375	Bolt Lathe		J. H. Johnston.	20 A.C.
376	Centering Machine		D. E. Whiton.	20 A.C.
377	Centering Machine		Pratt & Whitney.	20 A.C.
378	Bolt Lathe			20 A.C.
379	Bolt Lathe			20 A.C.
380	Stud Lathe		Smith & Coventry	20 A.C.
381	Nut Facer	¾-in. Nuts	Smith & Coventry	20 A.C.
382	Nut Facer	1½-in. Nuts	Smith & Coventry	20 A.C.

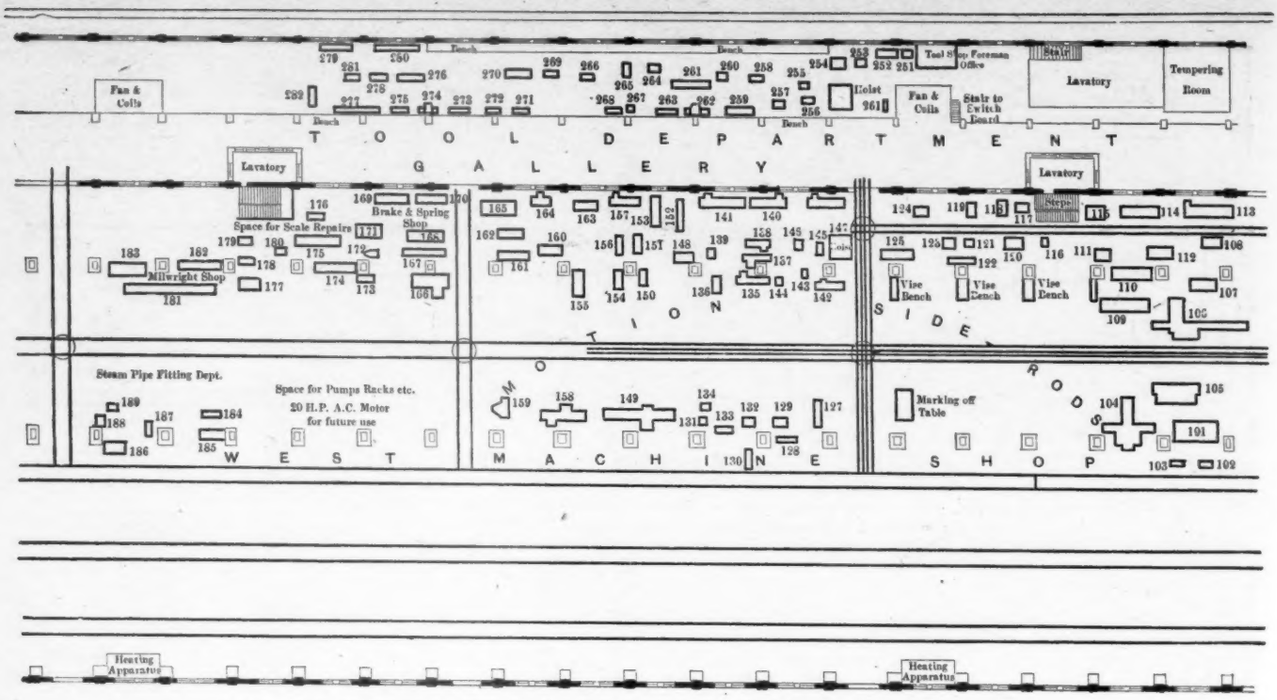
TIN SHOP.

401	Emery Wheel	12-in. wheel	Niles-B.-Pond.	10 A.C.
402	Press		Niagara Tool Co.	10 A.C.
403	Sheet Iron Shears.	63 in. wide	Niagara Tool Co.	10 A.C.
404	Punch	No. 122	Niagara Tool Co.	10 A.C.
405	Circular Shears		Brown, Boggs&Co.	10 A.C.
406	Bending Rolls	5 in.x72 in.	Scully Steel Co.	10 A.C.

go to the wheel department, which is close at hand, and after being finished they go to the cross tracks near the wheel shop, where the driving boxes are fitted to the driving wheels and made ready for the erecting shop.

The light parts, such as rods and motion work, are distributed in a rod department of about four bents, where this work is done within a radius of about 50 ft. The motion shop occupies about 10 bents, with cross benches and machines on both sides. One of the photographs shows these cross benches. All the benches are on the open floor, none of them being under the gallery. The driver brake, air pump and electric headlight work is provided for in the spaces beyond the motion department. The work benches are very substantial, consisting of 3-in. plank bolted to substantial cast iron supports, the supports being braced with ⅝-in. rods and held to the floor by lag screws. Each bench has two drawers, with substantial cast iron slides, which, when lubricated with graphite, work as easily as if they were on roller bearings. The top of the bench is of oak and the drawers of yellow pine. Each bench has also a yellow pine shelf below. They are sufficiently strong for heavy work. In the machine shop the benches are all out in the open. Wherever wall benches are used the construction is as shown in the engraving, which illustrates the bench used in the roundhouses of this road.

As far as possible material in this shop is kept off the floor. For holding the side and main rods of locomotives special tracks are provided in the erecting and machine shop. These are built with cast iron sections, very strongly braced, pro-



PLAN OF WEST END OF MACHINE SHOP, ALSO SHOWING GALLERY AND ERECTING SHOP.

ANGUS SHOPS, CANADIAN PACIFIC RAILWAY, MONTREAL.

WEST MACHINE SHOP.

Side Rod Department.

Mach. No.	Name.	Size.	Maker.	Motor. H. P. & Type.
101	Side Rod Drill	3 Spindles	Bertram	20 A.C.
102	Vertical Drill	36-in.	Bertram	
103	Vertical Drill	24-in.		
104	Miller	5 ft.x5 ft.x12 ft.	Ingersoll	
105	Side Rod Shaper	24-in.—2 heads	Bertram	2-5 A.C.
106	Double Planer	4 ft.x4 ft.x14 ft.	Pond	15 A.C. 2-2 A.C.
107	Turret Lathe	5-in.	Bardons & Oliver.	20 A.C.
108	Vertical Drill	40-in.	Bement Miles	
109	Double Slotter	12-in. stroke	Bertram	
110	Double Drill		Craven Bros.	
111	Vertical Drill	36-in.	Craven Bros.	
112	Slotter	16-in.	Bertram	
113	Double Planer			10 A.C.
114	Cotter Mill	4-Spindle		
115	Vertical Drill	40-in.	Bement Miles.	
116	Vertical Drill	24-in.		20 A.C.
117	Shaper	12-in.		
118	Shaper	24-in.	Bertram	
119	Crank Planer	18 in.x18 in.x18 in.	Bertram	
120	Chucking Lathe	24-in.	Craven Bros.	
121	Chucking Lathe	20-in.	Craven Bros.	
122	Engine Lathe	16 in.x5 ft. 6 in.	Gardner	
123	Chucking Lathe	24-in.	Craven Bros.	
124	Turret Boring Mill.	30-in.	Niles	
125	Engine Lathe	20 in.x5 ft.	McGregor	
126	Suspended Emery Wheel	20-in.	Bridgeport Co.	

Motion Department.

127	Side Bar Grinder		Bertram	20 A.C.
128	Engine Lathe	12 in.x2 ft. 6 in.	Smith & Coventry.	
129	Link Grinder	5-ft. radius	Smith & Coventry.	
130	Grindstone	6-ft.	Niles B. Pond.	
131	Double Buffer	30 in.x8 in.	Niles B. Pond.	
132	Emery Grinder	20-in. wheel	Can. Pac. Ry.	
133	Lapping Lathe			
134	Grinder	Lea No. 1	Anderson T. Co.	2 small D.C.
135	Engine Lathe	24 in.x5 ft. 4 in.	M'Greg. & Gourlay	20 A.C.
136	Shaper	24-in.	Flather	
137	Engine Lathe	18 in.x5 ft.	Bertram	
138	Engine Lathe	16 in.x5 ft.	Gardner	
139	Shaper	4-in.		
140	Engine Lathe	24 in.x6 ft.	Bertram	
141	Engine Lathe	30 ins.x8 ft. 6 in.	Bertram	
142	Engine Lathe	18 in.x3 ft. 6 in.	LeBlond	
143	Vertical Drill	20-in.	Craven Bros.	
144	Vertical Drill	20-in.	Craven Bros.	
145	Shaper	16-in.	Bertram	
146	Centering Machine		D. E. Whiton.	
147	Engine Lathe	22 in.x8 ft. 6 in.		
148	Vertical Drill	36-in.	Craven Bros.	
149	Planer	4 ft.x4 ft.x12 ft.	Flather	20 A.C.
150	Vertical Drill	24-in.	Craven Bros.	15 A.C.
151	Vertical Drill	36-in.	Craven Bros.	
152	Planer	2 ft.x2 ft.x6 ft.	Bertram	
153	Planer	2 ft.x2 ft.x4 ft.	Craven Bros.	
154	Vertical Drill	36-in.	Bertram	
155	Slotter	16-in.	Bertram	
156	Vertical Drill	36-in.	Bertram	
157	Engine Lathe	24 in.x5 ft. 6 in.	Gardner	
158	Extension Lathe	36 in.x72 in.x10 ft.	Bertram	10 A.C.
159	Boring Mill	51-in.	Niles	

Mach. No.	Name.	Size.	Maker.	Motors H. P. & Type.
160	Double Shaper	6-in.	Craven Bros.	15 A.C.
161	Turret Lathe	3 in.x36 in.	Pratt & Whitney.	
162	Turret Lathe	2in.x24 in.	A. Hebert	
163	Horz. Boring Mill.	3-in. bar	Bement Miles	
164	Cutting-Off Mach.	5-in.	Bertram	
165	Horz. Boring Mach.		Craven Bros.	

Brake, Spring and Manufacturing Department.

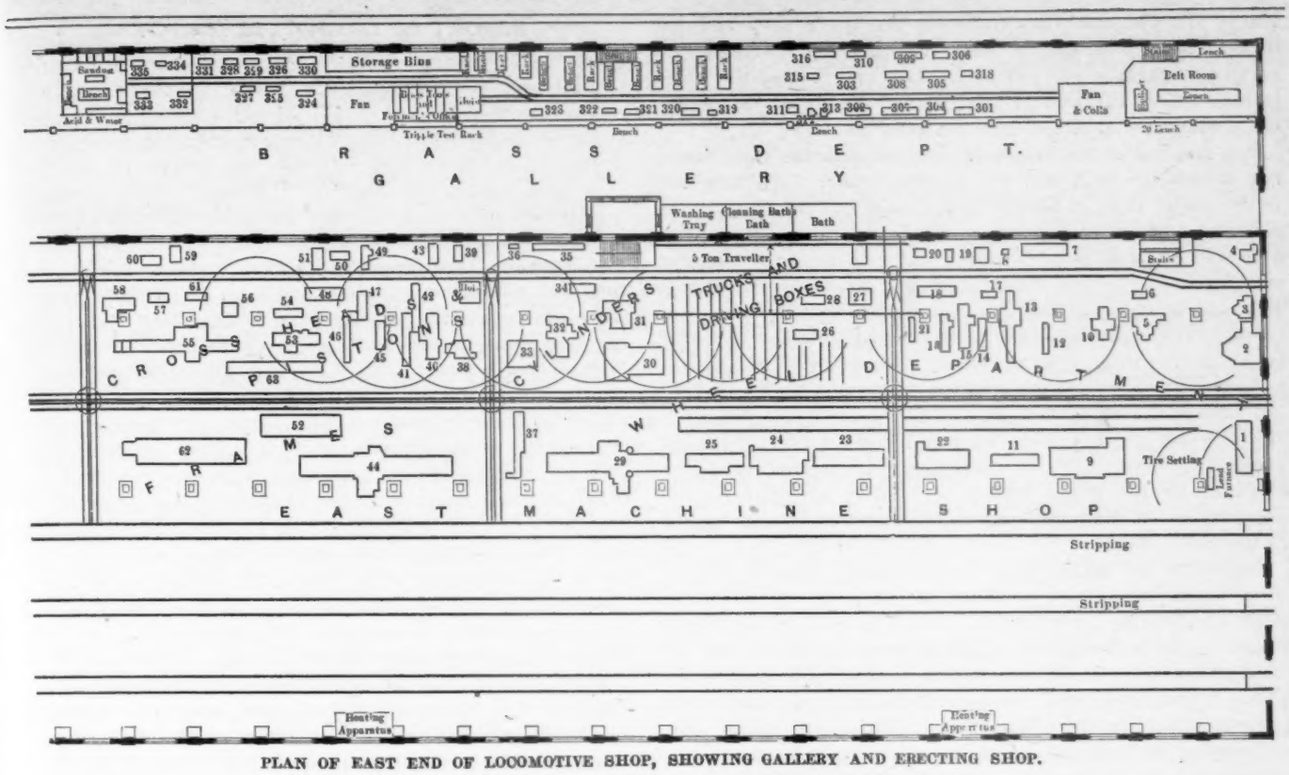
166	Radial Drill	5-ft.	Hulse & Co.	10 A.C.
167	Engine Lathe	24 in.x8 ft.	Bertram	
168	Double Shaper	14-in.		
169	Engine Lathe	20 in.x5 ft.		
170	Engine Lathe	30 in.x6 ft.	Bertram	
171	Vertical Drill	45-in.	Bertram	
172	Vertical Drill	36-in.	Bertram	10 A.C.
173	Vertical Drill	36-in.	Bertram	
174	Double Drill		Bertram	
175	Screwing Machine	3-in.	Smith & Beacock.	
176	4 Spindle Drill	Up to ½ in.	Foote Burt	
177	Slotter	12-in.	W. Collier	
178	Slotter	10-in.	W. Collier	
179	Slotter	10-in.	W. Collier	
180	Emery Grinder	20-in. wheel	Can. Pac. Ry.	
181	Engine Lathe	24 in.x22 ft.	Bertram	15 A.C.
182	Engine Lathe	24 in.x9 ft.	Smith & Coventry	
183	Horz. Boring Mach.	4 in.x9 ft.	Bertram	

Steam Fitting and Air Brake Department.

184	Engine Lathe	18 in.x3 ft. 6 in.	LeBlond	15 A.C.
185	Vertical Drill	36-in.	Bertram	
186	Pipe Threader	10-in.	Cox & Sons	
187	Pipe Threader	4-in.	Williams Tool Co	
188	Pipe Threader	4-in.	Armstrong	
189	Emery Wheel	12-in.	Can. Pac. Ry.	
190	Face Grinder		Iroquois Wheel Co.	15 A.C.
191	Drill Grinder	Yankee	Wilmarth&Morman	

Tool Department.

251	Emery Grinder	20-in. wheel	Can. Pac. Ry.	20 A.C.
252	Emery Grinder	20-in. wheel	Can. Pac. Ry.	
253	Tool Grinder	No. 2	Sellers.	
254	Tool Grinder	No. 1	Sellers.	
255	Drill Grinder		Sellers.	
256	Tool Grinder		Cincinnati.	
257	Universal Miller		LeBlond.	
258	Vertical Drill	30-in.	Bertram.	
259	Universal Grinder.	No. 7	Landis.	
260	Plain Miller		Bertram.	
261	Engine Lathe	22 in.x3 ft. 6 in.	LeBlond.	
262	Engine Lathe	20 in.x4 ft. 6 in.	LeBlond.	
263	Engine Lathe	14 in.x2 ft. 8 in.	Pratt & Whitney.	
264	Disc Grinder	No. 1	Chas. Besly	
265	Shaper	24-in.	Flather	
266	Vertical Drill	30-in.	Bertram.	
267	Tool Grinder	6-in. wheel		
268	Double Shaper	4-in.	Craven Bros.	
269	Universal Miller	No. 3	Cincinnati.	
270	Turret Lathe	2 in.x24 in.	Jones & Lamson.	
271	Engine Lathe	16 in.x3 ft.	Gardner.	
272	Engine Lathe	14 in.x3 ft.	Smith & Coventry.	
273	Engine Lathe	16 in.x2 ft.		
274	Engine Lathe	16 in.x3 ft.	Gardner.	20 A.C.
275	Engine Lathe	16 in.x3 ft.	Brown & Sharpe.	
276	Engine Lathe	16 in.x4 ft. 6 in.	Smith & Coventry.	
277	Engine Lathe	24 in.x10 ft.	Bertram.	
278	Engine Lathe	12 in.x3 ft.	Smith & Coventry.	
279	Hack Saw		Patterson Tool Co.	
280	Engine Lathe	18 in.x9 ft.	LeBlond.	
281	Engine Lathe	10 in.x3 ft.	Whitworth.	
282	Wet Grinder	42-in. wheel	Bridgeport.	



PLAN OF EAST END OF LOCOMOTIVE SHOP, SHOWING GALLERY AND ERECTING SHOP.

ANGUS SHOPS, CANADIAN PACIFIC RAILWAY, MONTREAL.

EAST MACHINE SHOP.

Wheel Department.

Mach. No.	Name.	Size.	Maker.	Motor. H. P. & Type.
1	Wheel Press	300 tons	Bertram	10 A.C.
2	Boring Mill	90-in.	Niles	20 D.C. / 2-5 D.C.
3	Boring Mill	51-in.	Bullard	10 D.C.
4	Boring Mill	51-in.	Niles	7.5 D.C.
5	Boring Mill	64-in.	Bertram	15 A.C.
6	Car Wheel Borer			
7	Engine Lathe	30 in.x4 ft.	Pond	
8	Emery Wheel	20-in. wheels	Niles-Be't Pond	
9	Wheel Lathe	90-in.	Niles	3 A.C. & 30 A.C.
10	Boring Mill	84-in.	Craven Bros.	15 A.C.
11	Quartering Machine	90-in.	Bertram	2-5 A.C.
12	Planer	4 ft.x4 ft.x12 ft.	Bertram	20 A.C.
13	Horz. Miller	42 in.x42 in.x14 ft.	Bement Miles	20 D.C.
14	Axle Lathe			30 A.C.
15	Axle Lathe	14 in.x8 ft.	Bertram	
16	Axle Lathe			
17	Shaper	24-in. stroke	Niles	
18	Planer	32 in.x32 in.x8 ft.	Craven Bros.	
19	Shaper	14-in. stroke	Craven Bros.	
20	Boring Mill	37-in.	Niles	
21	Radial Drill	4-ft.		
22	Wheel Lathe	72-in.	Bertram	30 A.C.
23	Wheel Lathe	84-in.	German Niles	
24	Wheel Lathe	84-in.		
25	Wheel Lathe	60-in.	Bertram	
26	Slotter	20-in. stroke	Bertram	10 A.C.
27	Vertical Drill	50-in.	Bement Miles	
28	Slotter	14-in.	Craven Bros.	

Cylinder and Frame Department.

Mach. No.	Name.	Size.	Maker.	Motor. H. P. & Type.
29	Planer	6 ft.x6 ft.x22 ft.	Pond	30 A.C. / 5 A.C.
30	Radial Drill	9-ft.	Bement Miles	5 A.C.
31	Radial Drill	6-ft.	Bertram	5 A.C.
32	Planer	5 ft.x5 ft.x8 ft.	Sharp, Stewart Co.	30 A.C.
33	Cylinder Borer		Craven Bros.	
34	Slotter	14-in. stroke	Newton	
35	Engine Lathe	24 in.x5 ft.	Lodge & Shipley	
36	Slotter for valve bush	5-in. stroke	Can. Pac. Ry.	
37	Cylinder Borer	3 bars	Bement Miles	10 D.C.
38	Boring Mill	60-in.	Niles	10 D.C.
39	Chucking Lathe	30-in.	Craven Bros.	20 A.C.
40	Extension Lathe	36 in.x72 in.x10 ft.	Bertram	
41	Engine Lathe	36 in.x9 ft. 6 in.	Pond	
42	Engine Lathe	24 in.x7 ft. 6 in.	Bertram	
43	Chucking Lathe	30-in.	Craven Bros.	
44	Planer, Frame	6 ft.x6 ft.x32 ft.	T. N. Shanks	20 A.C.
45	Chucking Lathe	36-in.	Craven Bros.	20 A.C.
46	Engine Lathe	30 in.x10 ft.	Pond	
47	Engine Lathe	30 in.x6 ft.	Stewart	
48	Planer	32 in.x32 in.x8 ft.	Craven Bros.	
49	Chucking Lathe	24 in.x4 ft.	Bertram	
50	Crank Planer	24 in.x24 in.x24 in.	Craven Bros.	
51	Drill	36-in.	Craven Bros.	
52	4-Spindle Drill	For Frames	Bement Miles	4-5 D.C
53	Extension Lathe	36 in.x72 in.x10 ft.	Bertram	30 A.C.
54	Horz. Boring Mill	4 in. bar x9 ft.	Binsse	
55	Planer	5 ft.x5 ft.x20 ft.	Bertram	
56	Vertical Miller	No. 6.	Becker Brainard	
57	Emery Grinder	20-in. wheel	Niles-Be't Pond	
58	Radial Drill	5-ft.	Hulse & Co.	
59	Shaper	24-in.	Flather	
60	Crank Planer	2 ft.x2 ft.x2 ft.	Craven Bros.	10 A.C.
61	Cotter Drill	No. 3.	Bement Miles	
62	Triple Slotter	24-in. stroke	Bertram	20 A.C.
63	Triple Slotter	8-in. stroke		10 A.C.

Brass Department.

Mach. No.	Name.	Size.	Maker.	Motor. H. P. & Type.
301	Engine Lathe	12 in.x3 ft. 9 in.	Bertram	20 A.C.
302	Turret Lathe	24-in.	Am. Tool Co.	
303	Forming Lathe	18-in.	Warner & Swasey	
304	Engine Lathe	20 in.x2 ft. 6 in.	Bertram	
305	Turret Lathe	24-in.	Smith & Coventry	
306	Turret Lathe	14-in.	Bertram	
307	Engine Lathe	24 in.x4 ft. 8 in.	LeBlond	
308	Turret Lathe	20-in.	Bertram	
309	Turret Lathe	22-in.	Bullard	
310	Turret Lathe	20-in.	Warner & Swasey	
311	Valve Miller	2 Spindles	Warner & Swasey	
312	Chucking Lathe	15-in.	Smith & Coventry	
313	Chucking Lathe	15-in.	Smith & Coventry	
314	Turret Lathe	16-in.	Smith & Coventry	
315	Turret Lathe	16-in.	Warner & Swasey	
316	Turret Lathe	16-in.	Smith & Coventry	
317	Emery Grinder	6-in. wheel	Can. Pac. Ry.	
318	Saw		Can. Pac. Ry.	
319	Valve Grinder		Warner & Swasey.	10 A.C.
320	Vertical Drill	30-in.	Bertram	
321	Forming Lathe	16-in.	Warner & Swasey.	
322	Turret Lathe	1 in.x10 in.	Pratt & Whitney.	
323	Disc. Grinder	No. 4	Charles Besly	
324	Sensitive Drill		Can. Pac. Ry.	
325	Speed Lathe	13-in.	Am. Tool Co.	
326	Turret Lathe	16-in.	Warner & Swasey	
327	Speed Lathe	13-in.	Am. Tool Co.	10 A.C.
328	Turret Lathe	16-in.	Smith & Coventry	
329	Turret Lathe	16-in.	Niles-B.-Pond	
330	4-Spindle Drill	To ½ in.	Foote Burt	
331	Turning Lathe	14-in.	Am. Tool Co.	
332	Buffer		Can. Pac. Ry.	20 A.C.
333	Buffer		Can. Pac. Ry.	
334	Buffer		Tacker Levett	
335	Buffer		Dickerman	

viding shelves for small material, and strong cast iron brackets for holding the rods themselves. From these brackets the rods are easily raised by the cranes. The drawing shows a cross-section, indicating the use of angles as braces, and showing the shelves, which are of 1-in. lumber. The benches are similar to those used at the Collinwood shops of the L. S. & M. S. Ry., and they were also used at the McKees Rocks shops of the P. & L. E. Ry.

This plan provides for heavy and light repairs of about 50 engines per month, and in addition to this about six new engines are built per month, which renders the matter of transporting material an exceedingly important one. The tonnage of material handled per month will approximate 600 tons. The average space provided per machine in the main machine shop, including the track area and truck shop, is

520 sq. ft. per machine. Omitting the truck shop and the through track area, but including the wheel storage space, 376 sq. ft. per machine was provided. The total area of the wheel storage tracks amounts to 1,805 sq. ft.; deducting this space, the actual floor area for each machine is 316 sq. ft.

The east end of the locomotive shop is near the store house, the blacksmith shop and the midway crane. All new material, except tires and boiler plate, comes to the shop at the east end. The tires are stored on a platform outside of the shop, and boiler material is stored out of doors at the west end of the shop. The new material is received under the cranes, and may be taken to any point in the building by cranes or trucks. The repair material is distributed from the stripping pit or the lye vats. The machinery was arranged to conserve as nearly as possible a systematic movement, keeping in view the importance of utilizing all of the space and keeping all of the heavy work under cranes and putting the light work under the gallery. The tool arrangement was influenced considerably by the group system of driving, and also by the necessity for mixing the work of manufacturing and repairs in the same plant.

Space will not permit of a complete description of the machine arrangement, but a glance at the plan will show the clear avenues for material which are maintained the whole length of the building. An example of the excellent arrangement of a group of machines is that of the wheel department, which is provided with its own cranes and is made independent of all the travelling cranes. The machinery of this department was located so as to minimize the distance of movement, and at the same time to provide sufficient space around the machines.

The boiler shop provides for tank and cab work, and the tube department. Tubes are rattled in a chain rattler, built from the design of Mr. G. R. Henderson, illustrated in this journal in June, 1904, page 220. This machine receives the tubes on a small car, picks up a complete set of tubes from the car, rattles them and loads them upon the car again. To unload the rattler and load it up again with another set of tubes ready for work requires six minutes. One of these rattlers is working very satisfactorily in the Topeka shops of the Atchison, Topeka & Santa Fe Railroad. The chains run at a speed of 115 ft. per minute, driven by a 20-h.p. motor.

The furnaces in the locomotive shop are of the Ferguson make, using oil fuel. The tube department is conveniently arranged, but is likely to be improved, with a view of reducing the cost of this work.

Electrical distribution begins at a large distributing board over the machine shop and east of the center of the building. The machine cables run down the columns in pipes and across to the machines under the floor. The alternating current motors are provided with compensators for starting, giving a large torque in order to start the machines under load. In a few cases the machines are equipped with ordinary switches. All of the controllers are of the Canadian General Electric Company's manufacture. The direct current motors have Canadian General Electric controllers for field control; their range in speed is 2 to 1, except one Milwaukee and one Westinghouse motor in the wheel department, having respectively a 4 to 1 and 2 to 1 variation.

In this magnificent shop a slightly increased expenditure would have been advantageous in increasing the proportion of variable speed driving. It would be easily possible to secure at least 10 per cent. increased output of many of the machines through more individual driving. In this entire shop there are but 9 variable speed D. C. motors applied to individual machines. This subject will be referred to again.

The output, organization and a description of the principle machine tools will be presented in the next installment. We are especially indebted to Mr. H. H. Vaughan, Mr. W. F. Connal and Mr. J. H. Morton for information connected with this description.

Mr. F. A. Delano has been elected vice-president of the Wabash system.

REPORT OF COMMITTEE ON POWER.

ROCK ISLAND COMPANY.

(*For previous article see page* 121.)

SUPERHEATING.

In the last three or four years considerable progress has been made abroad in the use of superheated steam for locomotives. The Germans have made the greatest advances in this direction, and at the present time have some fifty or more locomotives equipped with superheaters. The first two engines equipped with the Schmidt system were put into service in 1898 on the Prussian State Railways. These engines are still running, and after various modifications are reported as now giving satisfaction, and are to-day considered among the best of the engines for passenger service, in spite of the fact that they are in various respects not up to date in construction.

The present practice in Germany is to apply mostly the Schmidt system, but the Pielock is also used to a limited extent. The original Schmidt system consists briefly of a large flue in the lower part of the boiler with the superheater pipes located in the smokebox. In the later Schmidt design a number of 5-in. flues are located in the upper part of the boiler and the superheater pipes arranged inside these flues in groups of four. The Pielock design consists of a superheating chamber located in the barrel of the boiler, the boiler tubes passing through the chamber and expanded and set in the ends of the superheating chamber, as well as in the front and in the back flue sheets.

Some difficulty in American practice will probably be experienced with this form of superheater. The removal of the flues when heavily coated with scale may be attended with considerable difficulty and be a slow process. The expanding of the flues in the superheater chamber and the location of leaks into the chamber are difficulties which must be considered and met.

The advantages of superheated steam were very early recognized in the development of the steam engine, and numerous designs were made and in some cases patents obtained as far back as forty or fifty years ago. The use of superheaters in early days was very much handicapped by the use of vegetable and animal oils and inferior tubes. With the introduction of mineral oils of high fire test, which would not disintegrate at high temperature, and solid drawn seamless tubes, the way was opened for the successful use of superheaters.

Of the tests which have been made in Germany and for the last three years in this country, the facts must be established that the valves and cylinders can be properly lubricated by the use of suitable appliances and with mineral oil of high fire test, and the superheater pipes made of seamless tubes do not corrode and wear out with undue rapidity, but that a life of several years can be obtained from them.

Three engines have been equipped with superheaters on the Canadian Pacific Railway, one in June, 1901, at their Montreal shops, with the earlier Schmidt system, consisting of a large flue in the bottom of the boiler and the superheater pipes in smokebox; two ten-wheel compounds, one of which was built in Glasgow in 1903, and one at the Schenectady Works of the American Locomotive Company. These were equipped with the latest form of Schmidt superheater, in which the tubes of the superheater were located in groups of four in 5-in. flues, located in the upper part of the boiler. The reports indicate that the performance of all these engines has been quite satisfactory, and that a substantial saving in coal and water has been effected. The fuel reports show that a large saving in fuel was made in a period of over three years of superheater over a simple engine, and about 10 per cent. to 15 per cent. on the superheated compounds over the compounds without the superheater. (Since then more than 40 superheaters have been applied on that road. See AMERICAN ENGINEER, December, 1904, page 456.)

Apart from the saving in fuel, one of the greatest advantages of superheating is the use of dry steam in cylinders, as

it avoids many of the troubles due entirely to water, such as broken cylinders and heads, shocks and strains to piston rods, crank pins, crossheads, connecting rods, etc. It has been asserted by competent authority that it is practically impossible when running to carry water over into the cylinders, no matter how full the boiler may be. This alone is of great advantage, as a high water engineer can do no particular harm by carrying several inches too much water. With foaming water it would also appear to be of considerable value. It has been asserted by those who ought to know that, while the treatment of bad water decreases scaling very materially, the foaming is increased, rendering it necessary in some parts of New Mexico to run continually with the cylinder cocks open.

Superheating with piston valves is recommended, as the presence of water in cylinders of this type is liable to be much more detrimental than with slide valves. Furthermore, the balanced feature of the piston valve and probability of its more perfect lubrication are conditions which would make it appear desirable to use piston valves in connection with the superheater.

Saturated steam at 200 lbs. pressure has a temperature of 387 deg. Fahr. If superheated 175 deg. the temperature will be 562 deg., and it is obvious that 175 deg. of heat may be abstracted without decreasing the pressure. If, on the other hand, 175 deg. are taken from the saturated steam, the remaining temperature will be only 212 deg., or that of boiling water, and the pressure will consequently be zero. The thermo-dynamic efficiency of engines using superheated steam has never been questioned by engineers, and the advantages have been apparent for many years, but owing to failures which were met with many years ago, new experiments were usually discouraged on account of such failures. However, the experience in Germany has extended over six years in the use of superheated steam for locomotives, and it now appears that the earlier troubles have been largely overcome. It is reasonable to expect, however, that considerable changes in the method of application and design will be made in the next few years. There is no improvement in sight at the present time which offers so many advantages and so much economy, both in saving of fuel and water and the lessening of repairs, and from shocks and jars, due to presence of water in cylinders, as the application of superheaters. The experience in the last few years indicates very clearly that the additional complication to the boiler is comparatively slight, and that the superheater is not liable to require expensive repairs; nor has it been shown that failures in service may be expected.

The advantages of superheating were carefully considered by the American Locomotive Company, and a design was produced which seemed to be much simpler than any device hitherto prepared. In June, 1904, one engine of a lot of twenty for the New York Central was equipped at the Schenectady Works with a superheating device. (See AMERICAN ENGINEER September, 1904, page 338.) This engine went into passenger service, and has been running satisfactorily ever since. No trouble has ever been developed in the superheating arrangement, and only a slight difficulty was experienced in the lubricating device. The device applied to this engine seems to be much simpler and more straightforward than those designed abroad. The pipes require no bending, and can be removed in groups without disturbing the entire arrangement when repairs are necessary. The setting and adjustment is of the simplest possible nature, which can be readily done by the ordinary help in roundhouses. Orders have already been received for 26 of this type of superheater. (Many more have been ordered since this report was written.—EDITOR.)

In view of the promising results obtained from superheating, we recommend its application to a number of new locomotives, which will be required to take the place of the condemned engines, if the recommendations of the committee in regard to scrapping are carried out. As the conditions of service are so different on various parts of the Rock Island and 'Frisco systems, a test of only two or three locomotives might not be conclusive, and we would therefore recommend that a sufficient number be applied to get a thorough test under practical road conditions, incident to the Rock Island and 'Frisco systems.

BALANCED COMPOUND PASSENGER LOCOMOTIVES.

The characteristic and advantageous features of this type of engine, common to all builders, are as follows:

(a) Balancing of reciprocating parts by similar horizontal moving parts. One outside piston and its attachments moving forward while the inside one is moving backward. These balance one another without the use of unbalanced weights in the wheels.

(b) The increased weight permissible on the driving wheels when considered dynamically. In the ordinary engine, at 60 miles per hour, with drivers 78 ins. in diameter, the increase at each revolution at the static weights on the rail is about 23 per cent. This is due to the centrifugal effect of the excess weights used to balance the reciprocating parts.

(c) Increase of from 25 to 33 per cent. in sustained h.p. at moderate and high speeds without any material change in size or style of boiler.

(d) Economy in the use of fuel, water and steam.

(e) The advantages from light moving parts, such as cross heads, main rods, piston rods, etc. The lightness of these parts permits them to be easily handled and the probability is, as they only have to transmit one-half the usual amount of power, that the wear and repairs will be greatly decreased. The difference in the riding of these engines is very noticeable, running remarkably smoothly and easily at all speeds.

The greatest economy and refinement within the limits of good practice, as far as can now be seen, is the 4-cylinder balanced compound engine, equipped with superheater. As the additional weight of the superheater appliances is only about 2,000 lbs., there seems to be no practical difficulty in its application to an engine of this kind.

ELASTIC LIMIT OF AN AUDIENCE.

When an audience is tired out by the author of a paper who occupies too long a time in presenting his subject, the paper itself, if good, fails to receive the discussion which it merits, and the work of the organization suffers in many ways. Those in charge of meetings at which technical papers are presented would better serve the interests of individuals and the organizations if they would see that the speaker of the occasion appreciates the necessity of clear, definite and concise presentation. Many organizations in which our readers are interested provide in their by-laws for presentation of papers by abstract; but, how few observe the rule! It would be a real kindness to the author as well as the audience if the presiding officer would go to the speaker before the meeting and make sure that this is fully understood. Many good ideas fail to meet the reception they deserve because of a failure to appreciate the importance of the manner of presentation.

In an essay on "The Philosophy of Style" Herbert Spencer points out that "a reader or a listener has at each moment but a limited amount of mental power available," and therefore that it is important to economize his attention, because "the more time and attention it takes to receive and understand each sentence, the less time and attention can be given to the contained idea; and the less vividly will that idea be conceived." The purpose of any paper is always defeated when the audience is wearied by it. Preachers generally put up a silent petition before beginning their services, presumably for guidance in their ministration. It is suggested to the authors of technical papers that before they read them—or better still, before they are written—they offer up a petition somewhat to this effect: "From being a bore good Lord deliver me."